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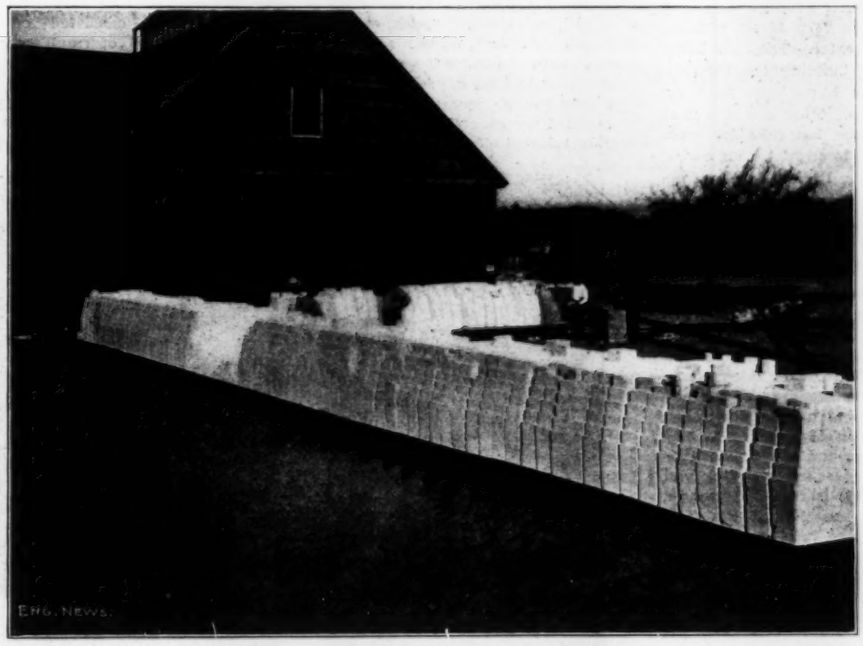
THE MANUFACTURE OF SAND-LIME BRICK.

Sand-lime bricks are bricks made from a mixture of sand and lime, molded in a press, and hardened by being subjected to steam heat under pressure in closed cylinders. The bricks can be made in many localities where ordinary clay bricks can only be obtained at considerable expense for freight charges, and the manufacture is very simple, while the long and expensive processes of drying and kiln burning are avoided. A lengthy article upon sand-lime bricks and their manufacture appeared in our issue of Jan. 22, 1903, and the results of tests made by Prof. Marston (of the Iowa State College) upon sand-lime bricks and concrete building blocks were given in our issue of April 21, 1904. At the end of 1903, two years after the introduction of sand-lime brick in this country, there were about 50 manufacturing plants, with a combined capacity of about 1,000,000 bricks per day. Since then the number has materially increased, and it is estimated that 100 plants are now in operation, having been established in various parts of the country.

The American Sand-Lime Brick Co., of Chicago, has already built 20 plants which are now in regular operation, and the following description relates to the design and equipment of one of this company's plants, all being built to about the same general plan. A clean sharp sand is required, and the best results are obtained with sand containing both coarse and fine grains. A special feature of this company's process is the use of hydrated lime, which avoids the possibility of injury due to the slacking of lime particles in the brick while under treatment in the cylinder. Both dolomite and high-calcium lime may be used, although the latter is preferable.

Fig. 1 is a typical plan of the plants built by this company, and Fig. 2 is a view showing different parts of the equipment referred to below. The sand is first passed through the dryer, and then elevated by the elevator, A, to the cooling room, as with the use of cooled sand the wear of the conveyor belts is reduced and the moisture is more easily regulated. From the cooling room the sand is delivered by a spout to the grinder, which is of special design for this work, and is an adaptation of the Chilean mill. The sand discharged from the grinder is again elevated by the elevator, B, to a storage bin over the machine room. The raw lime from the storage room is weighed out into small cars which are run into the brick hardening cylinder, where the lime is hydrated, as described more fully below. The cars are then run back, and the hydrated lime is passed through a pulverizer, from which it is raised by an elevator, C, to storage bins above the machine room.

From the overhead bins the ground sand and hydrated lime are delivered to a mixing machine, the proper proportions being regulated by a measuring device. The mixture contains from 4 to 10% of lime, according to the qualities of the sand and lime. This measuring device consists of a sliding hopper with two compartments, to which a horizontal reciprocating motion is given. At one end of the stroke the sand compartment is filled and the lime compartment discharges through a spout to the mixer; at the other end of the stroke, the sand is discharged while the lime compartment is refilled. The materials are screened before entering the hopper. The mixer is of the trough type, 16 ft. long, having a longitudinal shaft fitted with blades which mix the materials and gradually pass them to the discharge end, the mixture being then raised to the upper floor by the elevator, D. On this floor the mixture is first screened, then passed through a moistener, and then conveyed to the hopper of a Berg press, Fig. 3, in the vertical molds of which the bricks are formed by plungers above and below, worked by toggle arms. The pressure on each brick is from 75 to 125 tons, varying with the degree of moisture.



A CYLINDER CHARGE OF SAND-LIME BRICK.

As the bricks come from the press they are loaded upon iron flat cars, as shown in Fig. 2; these are then run into one of the two steel cylinders, which are 6 ft. diameter and 66 ft. 6 in. long. A single charge of brick is shown in the view on this page. The door of the cylinder is of steel, bolted and clamped to a steel ring on the cylinder; it is hinged at the top, being raised and lowered by a steel cable operated by power. The cars may be run in as fast as they are loaded, and the entire train is hauled out by a cable, the cables for the door and cars being operated by a steam winch shown on the plan, Fig. 1. Beneath the cars of brick are the cars of lime, with their wheels running on the flanges of the rails, and each lime car carries enough lime for a car of brick in the next charge. Fig. 2 shows the cylinder, with the door held open, and at its right is the cable for operating the door. In the cylinder may be seen a car of brick and a car of lime. At the right is the brick press, and the brick are being loaded upon a car, behind which is another lime car. Other lime cars stand near the turntable, the location of which will be understood from an inspection of Fig. 1.

A charge of 20 cars of brick, each car carrying 900 to 1,000 brick. When the cylinder is charged and the door closed, steam is admitted and a pressure of 120 to 125 lbs. maintained for about ten hours. As a rule, the brick are made during the day, and are kept under treatment during the night. In the morning the train of 20 cars is hauled out by the cable, and the bricks are stacked. They can be used at once, if necessary, but it is better to leave them for a day or two, as they dry out and become harder.

The machinery is driven by a 75-HP. engine, and steam for the engines and for the cylinder is furnished by a tubular boiler of about 150 HP. The necessary force comprises a foreman, day engineman, night fireman (to keep up the pressure for the cylinder), and eight laborers. These last

include two laborers handling sand, where (as is usually the case) the plant is located at the sand pit. The machine capacity of such a plant is 20,000 bricks per day, and the actual working capacity is about 18,000 brick per day. With lime at $4.50 to $5 per ton, the average cost of the bricks will be $3 to $4 per 1,000, if the plant is located at the sand bank or pit.

The bricks are of a uniform granite grey color, but coloring matter can be added to the mixture to produce any other color desired. They have a close grain and fine face, with sharp and strong edges and corners, so that they are suitable for face work in buildings. They are made to the standard size used in the district in which the plant is located, and their average weight is about 5 lbs. each. They are very dense, with an absorption of 5 to 10% of water. They are being very extensively used for building construction, and at Mobile, Ala., they have been used for sewers and sewer manholes. They are also used to some extent for sidewalks, but (like dry-press clay brick) are not adapted to street paving owing to their granular structure. Besides having high compressive strength, they have high fire-resisting properties (tests for which are to be made at Columbia University) and it is expected that they can be extensively used as fire-brick.

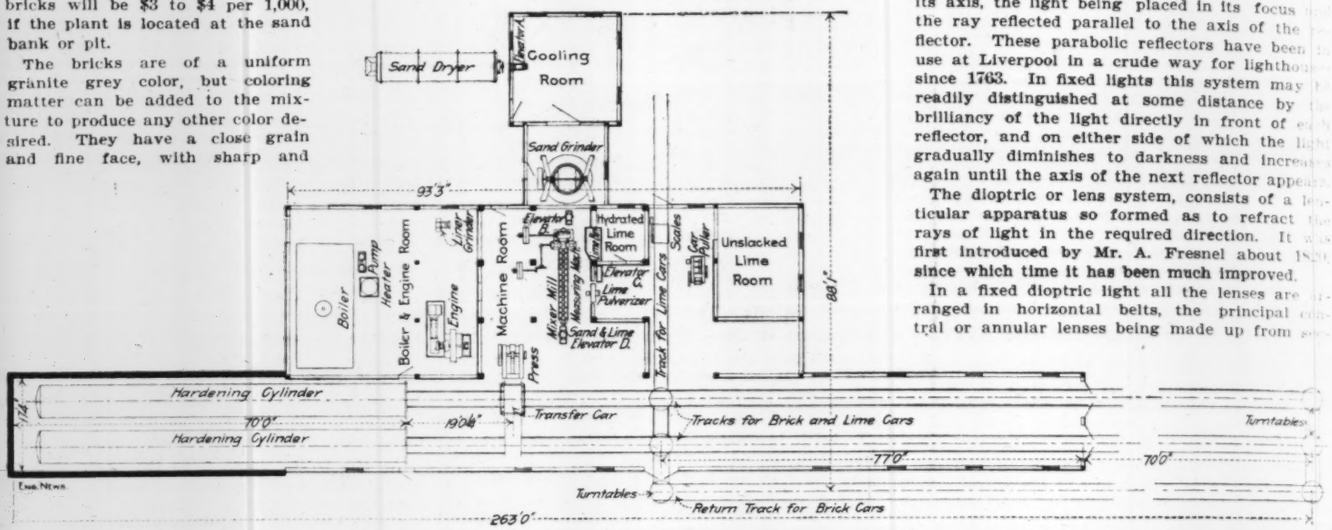


FIG. 1. PLAN OF SAND-LIME BRICK PLANT.

NOTES ON THE HISTORY OF LIGHTHOUSES.

By Robert A. Cummings,* M. Am. Soc. C. E.

From the time of the Pharos of Alexandria, which was one of the seven wonders of the ancient world, to the beginning of the nineteenth century, lighthouses were in the nature of elevated beacons with burning torches, or wood or coal fires. Of these, the oldest now existing and acting as a lighthouse proper is that of Corunna, northwest of Spain. The erection of the Cordoudan Tower at the mouth of the Gironde in the Bay of Biscay, and the structure on the famous Eddystone Rock, off Plymouth, England, really marks the beginning of modern lighthouses.

From a structural standpoint, the nautical lighthouse is exposed to great hydrodynamic forces. The experiments of the late Thomas Stevenson, in 1843-4, at Skerryvore Rocks, gave an average wave pressure of 611 lbs. p. sq. ft. during five summer months, and for six winter months an average of 2,086 lbs. p. sq. ft., the greatest force obtained in a gale being 6,083 lbs. p. sq. ft. It is also on record that the 400-lb. bell of the Bishop Rock lighthouse off Scilly, England, which is 145 feet above sea level, was torn away by a storm wave. However, there are few lighthouses in such exposed locations.

The use of open fireplaces burning wood or coal as marine beacons has not long been abolished, in fact, such fires were maintained on the two towers of Nidingen in the Cattegat in Europe until 1846.

The wax candles of the first Eddystone light and the use of oil lamps with reflectors furnished an improved means of illumination and increased the importance of lighthouses. By the introduction of the Argand lamps and illuminating gas another step was taken in advance, to be soon followed by the first introduction of electric light on Dec. 8, 1858, at the South Foreland lighthouse near Dover, England.

The isolated location of most lighthouses has hindered the adoption of the electric light and gas, although both possess several advantages over oil. At first, sperm oil was used extensively, then colza, rape-seed, and olive, until at the present time mineral oil is largely adopted. The only change necessitated by the substitution of mineral for vegetable oils is that the constant level of mineral oil should be below the top of the burner, while colza oil being viscous and less volatile, should be just above the top of the burner.

Two methods have been developed to more efficiently utilize the light by deflecting the rays and causing them to assume any desired direction, usually in a horizontal band of light. The catoptric or reflector system reflects the rays in the proper direction, and the dioptric or lens system deflects them by passage through some refracting medium.

The catoptric principle of reflectors is based upon the revolution of a parabolic curve on its axis, the light being placed in its focus so that the ray reflected parallel to the axis of the reflector. These parabolic reflectors have been in use at Liverpool in a crude way for lighthouses since 1763. In fixed lights this system may be readily distinguished at some distance by the brilliancy of the light directly in front of each reflector, and on either side of which the light gradually diminishes to darkness and increases again until the axis of the next reflector appears.

The dioptric or lens system, consists of a lenticular apparatus so formed as to refract the rays of light in the required direction. It was first introduced by Mr. A. Fresnel about 18[illegible] since which time it has been much improved.

In a fixed dioptric light all the lenses are arranged in horizontal belts, the principal central or annular lenses being made up from sections similar to that of the circular form of an ordinary plano-convex lens. In order to economize the light above and below the edges of the central annular lenses, the upper and lower portions consisted of catoptric reflecting zones formed of small separate mirrors to reflect the rays of light horizontally. Mr. Fresnel improved this by using catadioptric rings composed of glass lenses which reflected all the rays thrown on them. In a fixed light apparatus of the first order 19 of the catadioptric zones replaces 11 reflecting or catoptric zones. For revolving dioptric lights the central polyzonal lenses are built into square figures forming an octangular drum, which surrounds the central lamp placed in the common focus. As a further refinement Mr. Thos. Stevenson introduced the holophotal system, by which every portion of the light is econ-

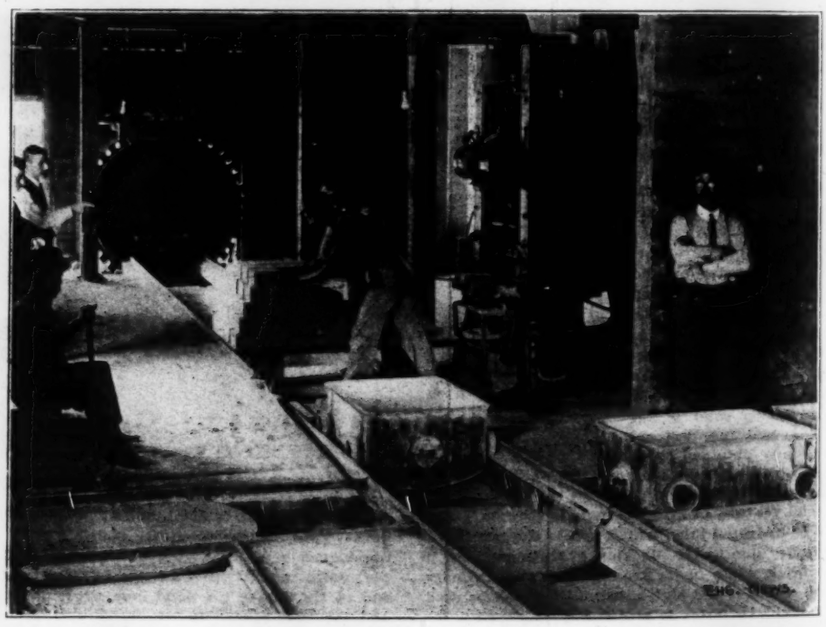


FIG. 2. INTERIOR OF SAND-LIME BRICK PLANT.

(The brick press is at the right, and in the background is the cylinder; the brick are piled on flat cars and the lime is hydrated in the small steel cars running beneath the brick cars.)

*House Building, Pittsburg, Pa.

omized by the addition of a glass refracting mirror behind and in the focus of the lamp. The whole of the direct rays from the lamp or the reflected rays from a posterior reflector are parallelized on their emergence. The distinguishing feature of the dioptric light is the whole luminous face when presented to any point.

These lights are rated as first order, second order, etc., approximately as follows: (1) 6 ft. diameter and 12 ft. high; (2) 4 ft. 7 ins. diameter; (3) 3 ft. 3⅜ ins. diameter; (4) 1 ft. 7⅝ ins. diameter; (5) 1 ft. 2½ ins. diameter; (6) 11¾ ins. diameter.

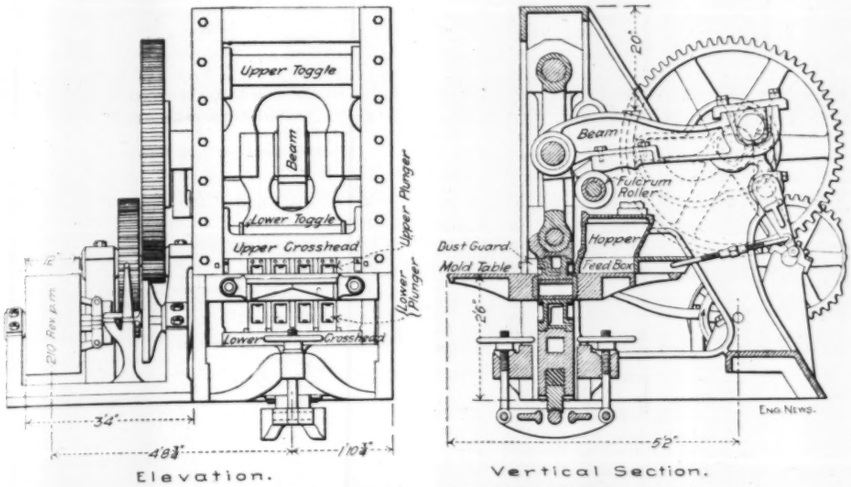


FIG. 3. THE BERG PRESS FOR SAND-LIME BRICK.
Anderson Foundry & Machine Works, Anderson, Ind.: Builders.

RIVER PROFILE WORK OF THE UNITED STATES GEOLOGICAL SURVEY, KENNEBEC RIVER, MAINE.*

By Arthur D. Butterfield,† and Geo. M. Brett.‡

During the year 1904, in connection with the stream measurements carried on by the hydrographic branch of the U. S. Geological Survey, river profile surveys were commenced in different parts of the country with a view to collecting information as regards the fall of certain rivers and the available water-power that might be developed. This information will be of general use in ascertaining how completely the present manufacturing establishments are using the power and also in indicating where further developments can be made.

The river profile work done in the eastern part of the United States was in Maine and confined to the Kennebec and Penobscot rivers.

In 1903, the topographic branch of the U. S. Geological Survey had obtained information and plans of the Kennebec River below Skowhegan and above The Forks to Moosehead Lake. Hence the work of 1904 was confined to the intervening portion, extending from the top of the dam at Skowhegan to the highway bridge at The Forks.

As the work was entirely of a new character only general instructions were given, leaving the details to be determined from the nature of the problems presented in the field. These general instructions were to obtain the profile of the river by carrying along a line of levels by the use of the transit, and taking the elevation of the water surface at least every mile and oftener if necessary. Also to make stadia surveys at points where in the judgment of the chief of party there was an evident chance for a power development plant.

ORGANIZATION OF FIELD PARTY AND METHOD OF WORK.—The personnel consisted of a chief of party, who directed the work and kept the notes; an instrumentman and two rodmen. Since the main object was to obtain a profile of the river, to this end was directed the most attention and other features were made of secondary importance. The control for the levels was a line of primary levels run by the topographic branch of the U. S. Geological Survey from Hallowell to Moosehead Lake, closely following the river. The part between Skowhegan and The Forks was used to check the river profile work.

This line of levels was run as a single rodded line from Hallowell to Moore's Island, four miles above North Anson. Then a single rodded line was run back from Solon Ferry, use being made of the adjusted Anson quadrangle levels established in 1903. From Solon a single rodded line was run north to Carratunk. From Carratunk to Moosehead Lake the levels were determined in 1903 in connection with the topographic work.

This primary leveling was done with a great deal of care, but it would not be classed as precise leveling. The instruments used were a 20-in Gurley Y-level fitted with stadia wires and a New York rod furnished with a plumbing level and a specially constructed foot plate. This foot plate was a truncated pyramid of brass, the bottom of which was but ½-in. in width so as to keep it freer of dirt and to compel its being placed more accurately on the top of the turning pin. The turning points were steel pegs 12 ins. long, driven firmly into the ground. The target readings were checked by the instrumentman and the fore and back distances read by means of the stadia wires and not allowed to differ by more than a very few feet. The sights were all less than 300 ft., except in special cases. The results of this primary line were permanent bench marks established at intervals of about three miles with temporary bench marks near the foot and top of falls or rips. The permanent bench marks were circular aluminum tablets, 3½ ins. in diameter and ¼-in. thick, appropriately lettered, having a 3-in. stem which was cemented into a drill hole in the vertical walls of foundations of buildings, bridge abutments, or the sides of large boulders. The elevation above mean sea level to the nearest foot and an abbreviation of the name of the datum point were stamped across the center. The center is the point whose elevation was determined. The temporary bench marks were points on boulders marked by white paint.

RIVER PLAN.—In order to determine a fairly accurate plan of the river from which to obtain distances for the profile, an azimuth line was carried, starting from an assumed azimuth at Skowhegan and reading stadia distances between stations. Prominent objects, such as trees, rocks, ledges, etc., on the opposite bank from which the stadia line was carried, were determined by the intersection of azimuths from two stations, and the river sketched in between these points and the stadia stations. In addition to this, the height of the banks was noted, their general slope and that of the land above them, and any item of interest which would serve to complete the topography. The instrument used for all the work was a new Berger transit with a 6-in. horizontal circle graduated to half minutes. It was also equipped with a full vertical circle and stadia wires. This instrument gave excellent service, holding well its adjustments, and deserves much of the credit for the results of the work.

The field routine was in general as follows: The rear rodman gave the back sight line for azimuth, and the stadia distance was obtained by setting targets on a Philadelphia rod equipped with two targets. The forward azimuth was then taken and the distance read from a self-reading rod. The magnetic bearings of both forward and back azimuth were taken as a check upon the azimuth work. While the rear rodman was coming up to the instrument station the azimuth readings were taken on points which served to determine the plan of the river, and the sketch made by the note-keeper. The levels were then run forward to the head station, using the transit to level with, water surfaces determined if necessary, and the time of day recorded when taken. The rear rodman served as rodman for the level line, the head rodman in the meantime having gone ahead with the canoe and selected the forward station. When the work was in the open and no reconnaissance necessary the head rodman assisted in the leveling. The levels were all taken "self-reading" on a Philadelphia rod and were read to hundredths.

PROFILE LEVEL WORK.—The profile leveling was done in three sections: (1) From Skowhegan to Solon Ferry, where the accumulated difference was 0.60 ft. small in 27 miles, so it was deemed best to start anew from that bench mark. (2) From Solon Ferry to Carrying Place Rips, where the accumulated difference was 0.18 ft. large in a distance of 18.5 miles, and a change was made before starting the stadia survey of Carrying Place Rips. (3) From Carrying Place Rips to The Forks, where the accumulated difference was 0.08 ft. large in a distance of 13.5 miles. Since the carried azimuth line in many cases ran ran along the shore of the river, water surface elevations were frequently taken and on the upper part of the survey, where the fall of the river was considerable, these readings were taken opposite nearly every stadia station. To enable these water surface elevations to be reduced to a common datum there were established at the beginning of the work nine river stations at which the water surface was read three times a day, usually about 7 a. m., 12 m. and 6 p. m. During the first half of the work logs were being driven down the river; hence, there occurred daily and rapid fluctuations in height due to what is locally called "the hoist." To determine whether "the hoist" had any noticeable influence on the average gage reading the whole period was separated into two parts; one while "the hoist" was in progress, the other the remaining time. The results show that the difference between the average gage readings of consecutive gages did not differ more than 0.1 or 0.2 ft. at the most, during the periods of "hoist" and natural flow. On this account the general average of the difference between the consecutive gage station readings has been taken. Starting with the average gage reading at Skowhegan these differences have been successively applied to determine a set of relative gage heights for the gaging stations along the river. Or, in other words, there was established a set of gage heights at which the water in the river was assumed to stand at the different gage stations, the river being under normal conditions of medium low water flow. The elevations of the different assumed standard gage heights were known since the elevation of the zero of the gage was determined by leveling.

*The same material was submitted to the Worcester Polytechnic Institute Journal, and published in practically the same form in that journal for July, 1905.—Ed.
†Professor of Mechanics and Geodesy and ‡Professor of Mathematics and Surveying, University of Vermont, Burlington, Vt. Professor Butterfield was in charge of the party which did the work here described.—Ed.

To obtain the river profile the following method was adopted. Since the time of day was noted when a water surface elevation was taken, interpolation was used to determine the water surface reading at the gage station at the time the water surface elevation was taken elsewhere. The elevation of the water surface was then corrected by the difference between the interpolated gage reading and the assumed standard gage reading. A single illustration will make clear the method: The water surface elevation opposite Station 37 at 3:40 p. m. was 141.38, as determined by the levels; gage reading at Norridgewock (nearest gage station) at 12 m. was 2.80 ft.; at 5:30 p. m. was 2.60 ft.; hence, the interpolated gage reading at Norridgewock at 3:40 p. m. is 2.67 ft. Correction to reduce to assumed standard gage height of 3.0 ft. is 0.33 ft. Therefore, the water surface elevation opposite Sta. 37 is 141.38 + .33 = 141.7 ft. under an assumed gage reading of 3.0 ft. at the Norridgewock gage.

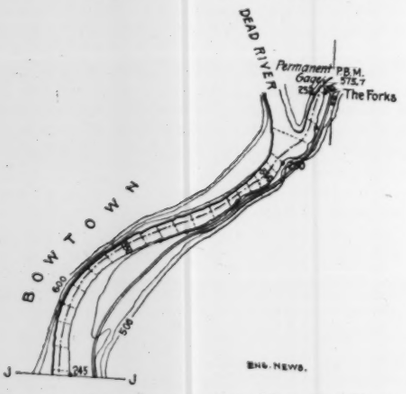


Fig. 1. Map of Portion of the Kennebec River.
(Black dots along the shore indicate stadia stations.)

The reductions for water surface elevations between gaging stations were usually referred to the nearest gaging stations. For those in the middle reductions for both gaging stations were made. These, in nearly all cases, agreed within 0.1 or 0.2 ft. In some few instances the disagreement amounted to nearly a foot, owing to "the hoist." Where there was any great disagreement between the two values as reduced from two gage stations the average was taken unless there was some good reason for preferring one over the other.

AZIMUTH WORK.—During the progress of the work there was developed the plan of making observations on Polaris at any time and determining the true azimuth of the line, thus giving a check on the carried azimuth. No observations were taken at the starting point, owing to the state of the weather and the undeveloped plan of the work. The first azimuth station was at Norridgewock, 4.7 miles above the starting point at Skowhegan. The method of making these observations was to occupy any stadia station and observe the angle between any reference line and Polaris, the time of observation being noted. Knowing the approximate position of the place of observation and the correction to watch time, the true azimuth of the reference line was computed. In these computations the tables given in Johnson's Surveying, pages 814-815, were used. The adjoined specimen (see next column) illustrates the form of observations and reductions.

This method of control work for long lines by observations on Polaris at any time ought to commend itself to all engineers and should be used by them more frequently than it is at present. It is easy, rapid, and accurate enough for most purposes, as the results are good, probably, to the nearest minute. The observer can take the observations at his convenience and the reductions can be made wholly by the use of the above mentioned tables or by those given in Gannett's Tables of Factors and Formulas, Bulletin No. 234 of the U. S. Geological Survey.

Summary of Azimuth Work.

Place of Observation.	Difference between true and assumed azimuth.	Distance in miles from the start.	Magnetic declination.
Sta. 32 at Norridgewock	17 33½	4.7	16 18 W
Sta. 99 at North Anson, near mouth of Carrabassett River	17 43	19.1	16 29 W
Sta. 158, 1¼ mile below Bingham	17 45	35.2	17 03 W
Sta. 213 at Carratunk, opposite Webster's Hotel	17 51½	50	17 05 W
Sta. 252 at The Forks	17 49	59.1	17 24 W

The summary shows that the maximum change in azimuth was 18 minutes and the accumulated change was 15½ minutes in the 59 miles.

STADIA SURVEYS.—At two places, Bombazee Rips in Norridgewock and Carrying Place Rips in Bingham, stadia surveys were made. The object of these surveys was to furnish detailed maps of these localities, with regard to the fall of the river, nature of the banks, topography, etc., from which preliminary locations of power development plants and estimates of their cost could be made. From the mouth of the Sandy River to Madison, while no regular stadia survey was made, enough work was done to connect this with surveys and plans made by the Great Northern Paper Co. At some few other places where development seemed possible sometime in the future enough general information was collected to give a good idea of the surroundings.

GENERAL RESULTS.—The time spent in the field was from July 12 to Sept. 1, inclusive, a total of 52 days, of which five were spent on stadia surveys of power sites. During this period 59 miles of profile were run and the plan of the river obtained, giving an average of 1¼ miles per day for total elapsed time, or 1.6 miles as an average for each actual working day, since actual field work was done only on 37 of the 47 days accountable to profile work. The carried azimuth line as run contained 252 stadia stations and covered a stadia distance of 59.1 miles, with an average stadia sight of 1,240 feet. The longest sight was 2,586 feet and the shortest 211 feet. The distance along the thread of the stream of the river as determined from the plan was 59.0 miles. The agreement between the levels as run by the transit and self-reading to hundredths, and those of the primary level party was remarkable. As previously noted they checked as follows: between Showhegan and Solon Ferry the profile party checked 0.6 ft. small in 27 miles. Between Solon Ferry and Carrying Place Rips they checked 0.18 ft. large in 18.5 miles. Between Carrying Place Rips and The Forks they checked 0.08 ft. large in a distance of 13.5 miles. In the total line the profile party ran 0.34 ft. small in 59 miles.

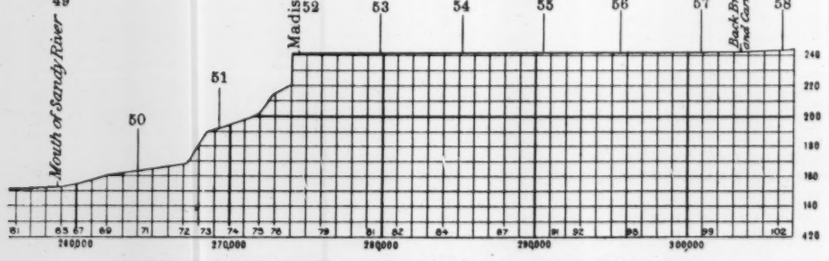


FIG. 2. PROFILE OF A PORTION OF THE KENNEBEC RIVER.
(The figures above are stadia station numbers; those at the side are elevations in feet; those at the base are miles and feet, respectively, from Augusta.)

SUMMARY OF THE FALL OF THE RIVER.—From Skowhegan to Norridgewock, a distance of about five miles, the water is practically at a level. From this place to the foot of Bombazee Rips the river rises 2 ft. in about 2½ miles. At Bombazee Rips there is a fall of about 7½ ft. in ¼ of a mile. This head could be further increased by a suitable dam. Between the mouth of the Sandy River and Madison there is a rise of about 68 ft. in a distance of 2½ miles. This locality offers the best attraction for power developments, as at various places there are good ledges for foundations of dams and the banks are steep and

Observation on Polaris for Azimuth.

Date—August 31, 1904.

Place—Stadia Station 252, The Forks, Me.

Reference Line—Stadia Station 252 to the N.E. corner of The Forks Postoffice, reading 0 00 00.

Observations by G. M. Brett.— Time P.M.	Angle.	Observations by A. D. Butterfield.— Time P.M.
h m s		h m s
6 59 28	200° 53′	7 14 54
7 01 00 Illumination West	53	15 48 Illumination West
01 40	53¼	16 20
02 22	54	16 49
03 02	54	17 39
06 30	53¼	18 20
07 33 Illumination East	54	19 00 Illumination East
11 10	54¼	19 26
11 58	54½	19 58
13 07	55	20 28

Watch 1 minute fast at time of observation.

Assumed position of station 45′ 19″ N. Lat. 69° 59″ W. Long.

Computations from G. M. Brett's Observations.

Average Time. h m		Average Angle 200° 53.8′
7 05.8		
1.0	Watch fast	
7 04.8		
20.1	Corr. for standard	
7 24.9	Local time	

From Johnson's Surveying.

Time of U. C. after mean noon.

	h m
Aug. 15, 1901	15 47.9
Tab. difference for 15 days	58.9
Aug. 30, 1901	14 49.0
Corr. to 1904	0.1
	14 48.9
24 00.0	
14 48.9	
9 11.1	Interval from U. C. to mean noon.
7 24.9	Time of observation after mean noon.
16 36.0	Hour angle.
23 56.1	
16 36.0	
7 20.1	Argument time from U. C.

Interpolated azimuth from Table, 1° 35.1′.

Computations from A. D. Butterfield's Observations.

Average Time. h m			Average Angle 200° 55.9′
7 18.0			
1.0			
7 17.0		9 11.1	
20.1	Corr. for standard.	7 37.1	
7 37.1	Local time.	16 48.2	Hour angle.
23 56.1			
16 48.2			
7 07.9	Argument time from U. C.		

Interpolated azimuth from Table, 1° 36.3′.

Angle from Northeast corner of The Forks Postoffice to true North.

By G. M. Brett.	By A. D. Butterfield.
200° 53.8′	200° 55.9′
1 35.1	1 36.3
199 18.7	199 19.6

Average, 199° 19′.

True azimuth Station 252 to N.E. corner of The Forks Postoffice	340° 41′
Magnetic azimuth from notes	358 30
Difference	17 49
True azimuth Station 252 to N.E. corner of The Forks Postoffice	340° 41′
Magnetic bearing Station 252 to N.E. corner of The Forks Postoffice	S 1 55 E
Magnetic declination is	17 24 W

high. A portion of this fall is now under development by the Great Northern Paper Co. which controls the power. At Madison there is now developed a fall of about 20 ft. Between Madison and Bingham there are now no undeveloped power sites. Between Bingham and The Forks there is a rise of 235 ft. in 23 miles, an average of 10 ft. to the mile. At only a few places are there rapids of a distinctive character other than the general slope. These places are, Gordon's Island, Hunnewell's Island, and Carrying Place Rips. This latter is the most promising place of the three, having now a fall of 9 ft. in a half mile. This could be increased by development.

MAPS.—The maps of this work were plotted on a scale of 1 to 24,000. Several different runs of river were plotted on the same sheet, the ends of the different sections being so marked that there would be no difficulty in joining them together. There are four such sheets and a profile. On these sheets were shown the outlines of the river banks, the islands, the position of rapids, falls, and existing dams, the crossings of all ferries, roads, railroads, and town boundaries, and all sections of the highway or railroad near the river. The river banks were contoured with an interval of 20 ft., while the river surface has 1 ft. contours drawn on it. In their proper positions on these sheets are marked the stadia stations and the elevations of the bench marks.

The work on the Penobscot River was in general like that on the Kennebec and the same methods were used. The survey extending from tide water at the Bangor Water-Works to Norcross. The maps of this work are not yet available.

The importance of the work is demonstrated by the number of calls for information respecting the surveys already made. The season of 1905 will probably see further surveys of this character in the state of Maine, and possibly some investigations along the line of improving water storage on some of the important power streams. For, while Maine is endowed naturally with some fine reservoirs for this purpose, and considerable artificial control already exists, there still remains much to be done in this line to improve present developed water powers.

PROPOSED GOVERNMENT INVESTIGATIONS ON FUELS AND STRUCTURAL MATERIALS.*

Two interesting features of the Louisiana Purchase Exposition were the United States fuel testing plant under the direction of the United States Geological Survey, and the collective Portland cement exhibit and model testing laboratory of the Association of American Portland Cement Manufacturers. These were working exhibits which accomplished much good in an educational way, besides yielding valuable data relative to fuels and the various building sands and gravels of this country; they were conducted with funds available only for the period of the exposition. The important results which were obtained, and the valuable data to be obtained through a continuance of this work, led to an earnest appeal to Congress on the part of Dr. Joseph A. Holmes† and many others interested in the work, which resulted in a liberal appropriation for the continuance of the investigations of fuels and structural materials on a much more extensive plan.

MORTAR AND CONCRETE MATERIALS.—With the appropriation for structural materials, which became available in March, 1905, it was decided for the present to confine the work, commenced during the exposition, to the investigation of sands, gravels, stone and other constituent materials of mortars and concretes, as well as to the study of mortars and concretes. The equipment of the model testing laboratory has been added to, and in this will be carried on the physical tests. In the metal pavilion, with a floor area approximately 59 ft × 100 ft., will be carried on tests of full size specimens. The chemical and microscopical laboratory occupies commodious quarters in the building used for a model foundry during the exposition. This work is under the direction of Mr. Richard L. Humphrey,‡ M. Am. Soc. C. E., and will include not only the work in the St. Louis laboratories, but that carried on under the direction of the Reclamation Service, United States Geological Survey, and the investigations at the various technological institutions, the latter in conjunction with the work of the joint committee on concrete and reinforced concrete.

The American Society of Civil Engineers about 18 months ago appointed a committee on concrete and reinforced concrete, with instructions to affiliate in its work with similar committees of the American Society for Testing Materials, the American Railway Engineering and Maintenance of Way Association and the Association of American Portland Cement Manufacturers. This joint committee appointed a sub-committee on tests, under whose direction was inaugurated a series of investigations in a number of technological institutions during the last school year. Owing to the insufficiency of funds for this purpose, and also by reason of incomplete inspection, and the untrained character of the students who made the tests, it was not deemed advisable to carry on this work very extensively under such conditions. At a meeting of the joint committee at Atlantic City, N. J., in June, 1905, it was decided to cooperate with the government in the investigation of structural materials, as far as they applied to concrete and reinforced concrete, and the government agreed to cooperate with the joint committee in carrying on such tests and in supervising the work at those technological institutions engaged in these investigations under the direction of the joint committee.

FUELS.—The systematic study of fuels from all parts of the United States, which was fairly started at the close of the exposition, has been continued on a more elaborate scale, especial attention being given to briquetting slack and refuse coal and also to the use of lignites in gas producers. The investigations during the exposition were carried on under the direction of a committee consisting of Dr. Edward W. Parker, Dr. Joseph A. Holmes and Mr. M. R. Campbell, of the United States Geological Survey; the work is now under the direct charge of Dr. Joseph A. Holmes.

TIMBER.—The investigation of timber (Prof. W. K. Hatt, Assoc. M. Soc. C. E., in charge) under the direction of Mr. Gifford Pinchot, is limited at present: (1) To those species which promise to be on the market for an indefinite period; (2) to actual market products, and (3) to such purely scientific work as forms the basis of correct methods of tests. This work is being carried on in the laboratories located at present at the University of California, Berkeley, Cal.; Purdue University, Lafayette, Ind., and Yale Forest School, New Haven, Conn.

The timber program also includes tests to determine the effect of artificial seasoning, such as is used in the operations preliminary to the preserving processes, and the effect of the presence of the preservatives themselves; this work is under the direction of Dr. H. Von Schrenk, being a continuance of experiments inaugurated during the exposition in timber treating and testing.

ADVISORY BOARD.—In order that the money available for the work outlined above, should be expended in such a way as to secure the most efficient results, it was thought advisable to create an advisory board composed of the various national societies directly interested, to whom could be referred the scope to be covered by the investigations, the methods to be used, and from whom could be obtained a critical opinion of the results obtained. Accordingly an invitation was extended by the Secretary of the Interior, with the endorsement of the Secretary of Agriculture, to the various national societies, requesting their president or some other representative to serve on an advisory board for the investigation of fuels and structural materials. In response to this invitation a meeting was held in Washington, D. C., on June 3, 1905, in the office of the Director of the United States Geological Survey, at which meeting were present the advisory board organized by the election of Dr. Charles B. Dudley, M. Am. Soc. C. E., President, and Mr. Richard L. Humphrey, M. Am. Soc. C. E., Secretary.

The following national societies are represented on this advisory board:

The American Society for Testing Materials.
American Society of Civil Engineers.
American Society of Electrical Engineers.
American Society of Mechanical Engineers.
American Institute of Mining Engineers.
American Institute of Architects.
American Railway Engineering and Maintenance of Way Association.
American Railway Master Mechanics' Association.
Association of American Portland Cement Manufacturers.
Geological Society of America.
National Association of Cement Users.
National Board of Fire Underwriters.
National Fire Protection Association.
National Lumber Manufacturers' Association.

There is also associated with this advisory board a representative from each of the following branches of the government: Bureau of Yards and Docks, U. S. N.; Corps of Engineers, U. S A; Forestry Service; Geological Survey; Isthmian Canal Commission; Reclamation Service; Supervising Architect.

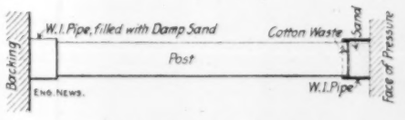
The advisory board is expected to be a continuous one and will supervise what it is hoped will be an exhaustive series of investigations of fuels and structural materials. The board will not only pass on the plan and methods for carrying on the work, but will also pass on the advance results of the tests, and the various branches will thus have the benefit of the advice of the foremost engineers of this country.

It is the first time in the history of the United States Government that such extensive cooperation has been effected with ouside engineers, although the plan has long been in use in European countries. Such close relations between the users of the materials of construction and the branches of the government engaged in testing such materials it is believed will result in more expeditious and satisfactory work and will prove of great economic advantage to both public and private interests. Heretofore such investigations have been conducted by those in the employ of the producer or consumer at such times and under such conditions as would not seriously interfere with routine work. They were, therefore, necessarily incomplete, and lacked the thoroughness desirable. The present investigations will be conducted by a disinterested and wholly impartial party, and possessing the requisite time and money, and the results should therefore prove invaluable.

*Statement from Advisory Board of U. S. Geological Survey, having in charge investigations of fuels and structural materials.
†Chief of the Department of Mines of the Exposition and Fuel Expert of the United States Geological Survey.
‡Consulting Engineer, Harrison Building, Philadelphia, Pa.

A SIMPLE METHOD OF SECURING UNIFORM LOADING IN COMPRESSION TESTS OF REINFORCED CONCRETE POSTS.

The accompanying sketch shows the method adopted by Mr. Mason D. Pratt, M. Am. Soc. C. E., of Harrisburg, Pa., to secure uniform face pressure in testing concrete posts. The occasion of devising this method was the manufacture of about a thousand reinforced concrete posts 6 ins. in diameter and 4 ft. long. It was necessary to test samples of these posts, and to perform the task without involving much labor or expense in preparing the test pieces. The method adopted



Method of Testing Reinforced Concrete Posts.

was to seat the ends of the posts in sand boxes and Mr. Pratt states that the ease with which the test pieces could be adjusted in the press and secure a uniform pressure over the entire face of the post regardless of the conditions of the face was highly satisfactory. He also believes that a similar scheme could be used in testing short cubes and cylinders and better results obtained than by using blotting paper, pads and other familiar devices.

A HINT TO USERS OF WATER WHEELS.

By F. M. G.

A journal of so varied and so numerous readers as the "Engineering News" must have, among others, mill superintendents and millwrights, to whom, in the course of their duties, comes the agreeable task of replacing burned-out water wheel steps. It is doubtful if any other piece of machinery, when it does take to being eccentric, can be the cause of more concentrated trouble than this innocent appearing block of lignum vitae when it goes on its travels in the midst of the wheel case.

This summer, "way down in Maine," I had the pleasure of meeting a mill superintendent whose plant carries several high powered turbines, on vertical shafts, under a fall of some 28 or 30 ft. To the elect it will be seen at once that here are all the factors for the most approved brand of wheel trouble, but it is the boast of the gentleman in question that a burned out step or other trouble with the bearing is of the least of his worries, and the record of the plant under his direction goes to prove the assertion. This gentleman willingly consented to give his secret to the professional world, and I take pleasure in making it available through your columns.

In brief, Mr. A. simply cuts across the bearing surface of the step three or four deep grooves, radially. These grooves are of generous depth and width, say ¾ and ½-in., respectively. It would appear that their action is to allow free access of the water to the bearing surface of the step, aided possibly by a more or less energetic circulation through the grooves, thus keeping down the temperature. However it may be, the fact remains that the device is most effectual.

THE GROWTH OF LARGE GAS ENGINES ON THE CONTINENT.*

By M. Rodolphe E. Mathot.†

As large gas engines have now won an important place in industry it will be of interest to cast a retrospective glance at their evolution. So long as town gas was the fuel "par excellence" for industrial engines, by reason of the faculty attending its use, the applications of the explosion engine were limited to 50 to 75 HP., beyond which the cost of working was found to be excessive. Poor gas produced under pressure with the old apparatus of the Dowson type enabled one, it is true, to venture upon 75 to 100 HP. and even greater powers with more practical results; but the complication of the gas generating apparatus, the initial cost, and the space taken up by the producer plant and engine rarely compared favorably with the steam engine and boiler. The latter, moreover, adapts itself better to every class of fuel, whether gaseous, liquid or solid. Among solid fuels coal dust, as also peat, vegetable waste, straw and sawdust, constitute very advantageous fuels without requiring complicated and troublesome furnaces.

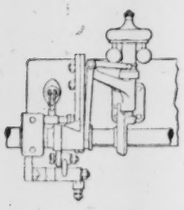


Fig. 1. Conical Cam for Variable Gas Admission.

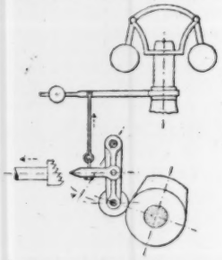


Fig. 2. Stepped Pecker Block for Variable Gas Admission.

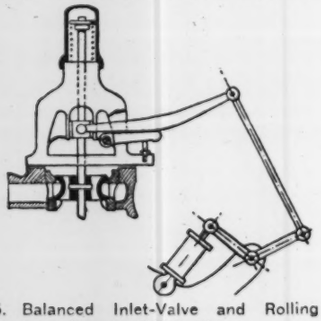


Fig. 5. Balanced Inlet-Valve and Rolling Path Lever. (Winterthur.)

In order to compete successfully with the steam engine, the explosion motor required to be provided with cheap gas, easy of production by means of simple and economical apparatus. Suction gas producers have decided the question for the industry in general, while the purifying and washing processes for blast furnace gas, coke oven gas, etc., have, in an unexpected manner, brought about the possibility of applying explosion engines to the greatest motive powers required in the metallurgical industry. While in electric lighting stations the steam engine, in spite of its great regularity in work, encountered a serious rival in the gas engine, the petrol engine has decided the question of road locomotion. Motoring, thanks to the wonderful attributes of small engines, has led to the application of internal combustion engines for this purpose. Submarines have already been fitted with these engines, and it is safe to predict that at no remote date the explosion engine will take its place in the mercantile marine, side by side with powerful steam engines, for the propulsion of our vessels.

The development of large gas engines can be said not to date back further than five to six years. Eight to ten years ago they were initiated simultaneously in Germany, England and Belgium, early attempts being made to utilize blast furnace gas, which was expected to open up such a vast field for the employment of large engines. Although the first trials were only attempted on small engines, the results of the experiments soon gave encouragement to the efforts of the investigatore. The Cockerill Co., of Belgium, constructed a single acting Otto cycle engine of 200 HP., which has been working regularly at their establishment for six years. This stage in the path of progress was strongly accentuated by the 600-HP. engine on the Delamarre-Debouttéville system, which the Cockerill Co. exhibited at the Universal Exhibition at Paris in 1900. This magnificent engine was single acting, the piston having a diameter of 1.3 m. (4 ft. 3 3-16 ins.) and a stroke of 1.4 m. (4 ft. 7¼ ins.). It was designed to develop its power at 80 revolutions per minute, which, with an initial explosive pressure of 310 to 325 lbs. per sq. in., produced on the piston a pressure of 300 tons at each explosion. In a short time several famous firms entered, in their turn, upon the construction of large engines intended to utilize the gases liberated by the various reactions occurring in the manufacture of iron, coke, etc., and the metallurgical industry was not long in entering upon the path of progress by replacing for its old boilers and engines powerful installations of explosion engines. It remained, however, to conquer the vast domain of manufacturing industry. It is in this sphere that the struggle is taking place with the steam engine, which a long career has endowed with improvements in methods and execution. The physical laws which govern the production and utilization of steam as a motive power have long been known, having at an early date emerged from the obscurity which enveloped their interpretation, and thermodynamic science has given them definite sanction by numerous investigations.

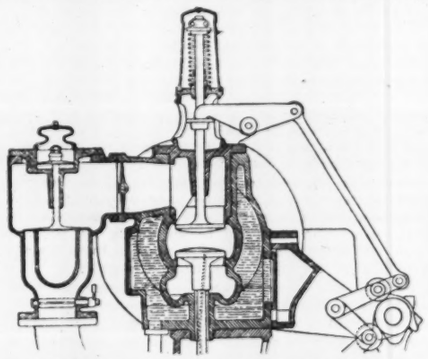


Fig. 3. Mixing-Valve and Throttling Butterfly-Valve. (Benz.)

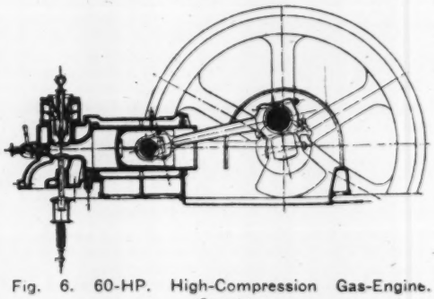


Fig. 6. 60-HP. High-Compression Gas-Engine. (Soest.)

Improvements in construction advanced side by side with the progress of scientific theory to accomplish mechanical marvels. Steam, is, however, a fluid complex in nature than explosive mixtures. The steam is governed by precise laws which pertain the sphere of physics, while the production of gases and their mode of evolution under the explosive mixtures in engines, are as much domain of chemistry as of physics and mecha though the generic theory of gas engines has the present on a series of hypotheses which ha received experimental confirmation, these eng gained ground in application to various industries exceptional rapidity compared with any other kind tive power. The invention of gas producers and improvements made in the last few years, and in those working with the direct suction of the are manifestly most important factors in this

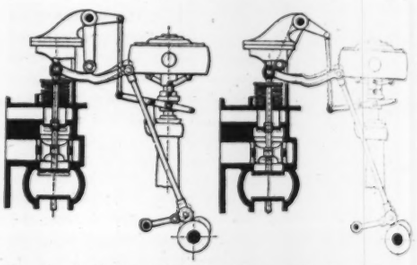


Fig. 4. Variable Admission-Valve with Stroke controlled by the Governor. (Otto-Deutz.)

Before examining the successive developments of these producers, the principal phases of the improvements through which the engines themselves have passed will be analyzed. It was first of all in Germany and then in England that their construction underwent the most rapid development. Afterwards America was the country which produced the greatest number. It is therefore not surprising to notice that each type has retained in its construction or design something which, as a birthmark, reveals its nationality. The German engine has always presented the appearance of a well-finished machine as regards constructional details—all the parts machined were usually polished bright, which disclosed a real anxiety on the part of the makers to impart a high finish to their machines. This, of course, affected the price, but the life of the engine was materially increased thereby. There are cited as examples of longevity certain "rack" engines of the Otto-Langen type and make, which are completing a career of 30 years' service.

The English makers took up another position, namely, that of producing cheaply in order to produce on a large scale. Thus we are indebted to them to a great extent for the propagation of small engines for industrial purposes. This was a fertile field for investigation and experiment, which our makers, deeply immersed in the construction of powerful engines, have often failed sufficiently to notice. English engines, designed for the use of town gas, vie with each other in ingenuity in the arrangement of their parts in order to attain efficient and simple mechanical devices. The lift of the valves and their mode of operation are in general obtained by cam and lever movements with a definite movement giving a positive action. The governor itself is reduced to its most simple expression.

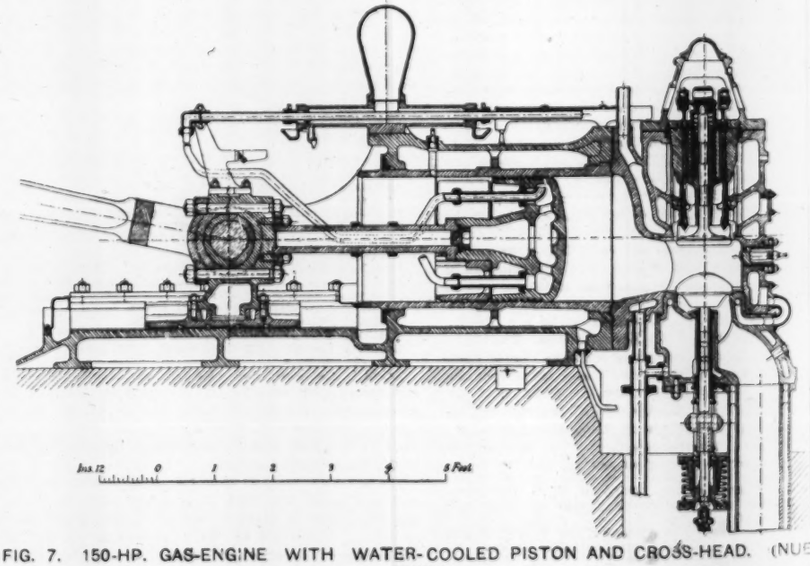


FIG. 7. 150-HP. GAS-ENGINE WITH WATER-COOLED PISTON AND CROSS-HEAD. (NUERNBERG.)

*Paper read at the Liege meeting of the Institution of Mechanical Engineers of Great Britain, 1905.
†Brussels, Belgium.

since in the "hit-and-miss" arrangement its action consists merely in displacing to a slight extent a small piece which is normally interposed at the point of contact between the controlling lever and the stem or spindle of the gas valve in order to open it or to leave it closed, and which transmits the motion by which the valve is opened; when the piece is displaced the motion is no longer transmitted. Unfortunately, this type of governing is not compatible with the requirements of the working conditions of modern large engines.

The English makers are familiar with the series of very special phenomena produced by the system of "hit-and-miss" regulation. In particular they are aware:

(1) That after a stroke with no charge the following explosion is more powerful in certain cases and weaker in others, according to the form and the arrangement of the explosion chamber and its ports.

(2) That violent explosions are often produced, the consequences of which are the more injurious to the life of the working parts as the engines are larger and consequently oppose the inertia of heavier masses to movement.

(3) That the intermittence of the explosions produces cyclic variations or irregularities in the revolutions of the fly-wheel regarded individually, and that these irregularities are incompatible with the working conditions of dynamos for lighting, etc.

(4) That in order to overcome these difficulties it is necessary to use extra heavy fly-wheels, which constitute an additional load on the engine and cause a reduction of mechanical efficiency.

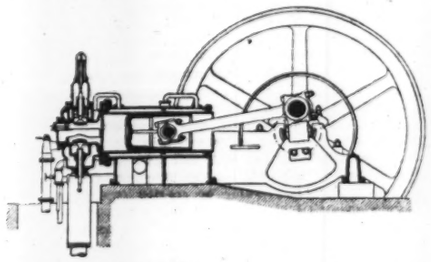


Fig. 8. Internal Water-Cooling Arrangement. (Koerting.)

As against these defects it will, it is true, be contended that the "hit-and-miss" constitutes the simplest form of governing as regards construction, the least liable to get out of order, that it keeps within very small limits the variations of speed resulting from alterations of load, and that it is the mode of regulation which secures the lowest consumptions at the different speeds, because with a constant charge the latter is always properly proportioned and is fixed once and for all. It must, however, be recognized that if this system has so far satisfied the conditions required in the case of small engines for industrial purposes, which have for a long time made the reputation of the English makers, it is incompatible with what should be obtained from large engines of hundreds or thousands of horse-power, if they are to compete with the steam engine as prime movers.

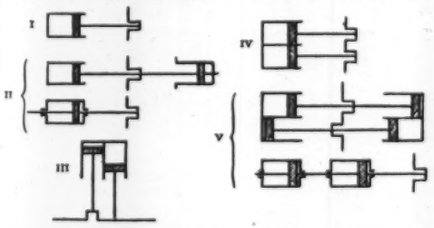


Fig. 10. Diagrams of Cylinder Positions Relating to Calculation of Fly-Wheels.

The merit of having entered upon the new path which the construction of gas engines has followed for five or six years undoubtedly belongs to the Germans. The old makers of gas engines in Germany took the initiative of departing from old methods. In a short time their processes were themselves improved and perfected by the makers of steam engines, long accustomed to circumvent or overcome practical difficulties in the construction of large engines. Without large gas engines tending towards a single type it may be said that they all have manifest tendencies to resemble the modern steam engine from the point of view of their form and valve gear. Having regard to the fact that valves are the common means of distribution, that they are operated by a side shaft, and that large engines now work double acting it was natural and logical that the explosion machine should borrow from the steam engine the design and methods with which it has been equipped in its long and victorious career. The introduction and growth of suction gas producers and the utilization of blast furnace gas, coke oven gas, etc., which have marked the development of large gas engines, have led to the creation of different designs for their construction. Different principles have thus been modified in their applications, such as the regulation, the compression, the cooling, the ignition. Without dwelling upon the different stages of their transformation, it will be shown in what way modern methods differ from old methods, and the probable direction of future change, having regard to the knowledge and practical experience already acquired.

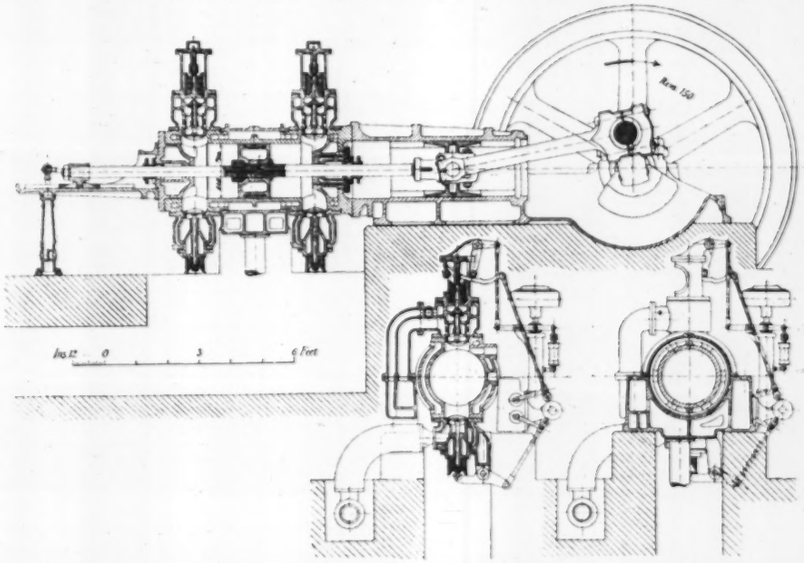


FIG. 9. 200-HP. DOUBLE-ACTING GAS-ENGINE. (OTTO-DEUTZ.)

REGULATION.—For the reasons which have been enumerated, the "hit-and-miss" system of regulation has been completely abandoned. This system, moreover, does not lend itself to working with very light charges, or with no charge, in the case of engines fed by suction gas producers. As in these circumstances the gas supply alternates with three, four or even five strokes with no charge, it happens that the suction which determines the supply of air to the producer is not sufficiently uniform, and that the fire finishes by being extinguished, or, to say the least, by producing a very poor gas through the lack of activity in the furnace. German makers then invented the conical cam for the admission of the gas, Fig. 1, which, being displaced by the action of the governor, produced variable lift of the gas valve. But this device was only a variation of the stepped cam or of the stepped pecker block, Fig. 2, which the English makers had tried in their electric types, and they soon discovered the uneconomical results it caused. The stepped arrangement had the advantage over the conical cam of lessening the work upon the governor. But, as both systems acted on the quantity of gas admitted, while the quantity of air of the mixture remained constant, mixtures of variable composition—often too rich in the case of a full charge, and always too poor with the weak charge—were formed. In the latter cases the ignitions were tardy, the diagrams bad, and the efficiency less as the charge was reduced in richness. While with a good engine regulated by the "hit-and-miss" system the consumption at half load, which from the industrial point of view is the most interesting, was not more than about 20% higher per HP.-hour than with full load, it became 40 to 50% higher with an engine with variable mixture.

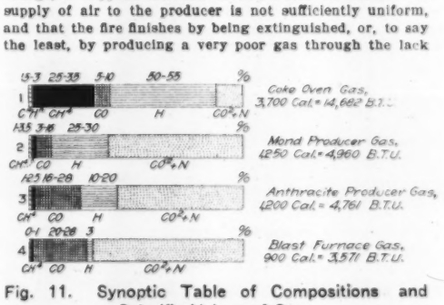

Coke Oven Gas, 3,700 Cal.= 14,662 B.T.U.
Mond Producer Gas, 1250 Cal.= 4,960 B.T.U.
Anthracite Producer Gas, 1200 Cal.= 4,761 B.T.U.
Blast Furnace Gas, 900 Cal.= 3,571 B.T.U.

Fig. 11. Synoptic Table of Compositions and Calorific Values of Gas.

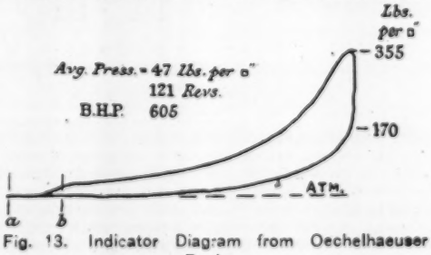


Fig. 13. Indicator Diagram from Oechelhaeuser Engine.

It is, therefore, towards the system of admission of a variable quantity of mixture, but of uniform composition, that makers have directed their path. A few English makers, Tangye, Willans and Robinson, also Westinghouse, decided the question by throttling, by means of a butterfly valve or a cylindrical slide valve, the mixture regulated in advance; this butterfly valve or slide valve being controlled by the governor and placed immediately before the valve admitting the mixture to the cylinder. The principle was still further improved by an automatic mixing valve, preceding this regulating device, Fig. 3, as constructed by Benz in his four-cycle engines. However, the majority of the Continental makers, with the object of obtaining a prompter and more reliable action of the governor, have endeavored to combine under one single control and in a single device the slide or inlet valve and the mixing valve, and, instead of throttling the charge in the passage, they have provided the mixing valve with a variable stroke under the action of the governor, Fig. 4. The application of this device has not, however, been extended to very large engines, as it was found to be too heavy and cumbersome to handle and dismantle for the purposes of cleaning. Admission in variable quantity of a uniform mixture involves variable compression and the necessity of a high original compression. If for the full

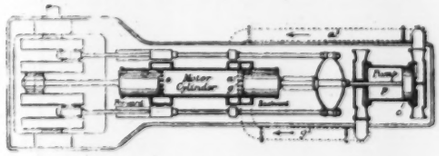


Fig. 12. Diagram Plan of Oechelhauser Engine.

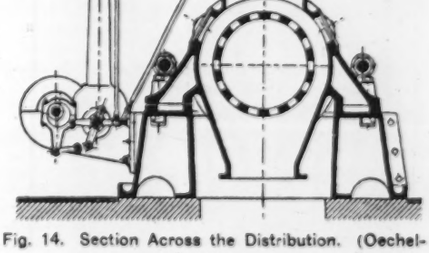


Fig. 14. Section Across the Distribution. (Oechelhaeuser.)

admission of the charge this compression was from 170 to 200 lbs. per sq. in., it might fall to less than 45 to 55 lbs. per sq. in. for the minimum admissions, which would interfere with the prompt ignition of the very poor mixtures which are at the present time used in engines applied for industrial purposes. Further, this mode of admission produces at the time of the suction with light charges, a vacuum or negative work which would become considerable in engines of high power. This has been avoided by combining with the variable admission of the constant mixture an additional admission of air or impoverished mixture, in order to effect at the same time the constant compression and minimum vacuum in the cylinder. The firms of Cockerill and Nürnberger Maschinenbau have, as the author foretold three years ago in "Power" of New York, already adopted mechanism for this purpose.

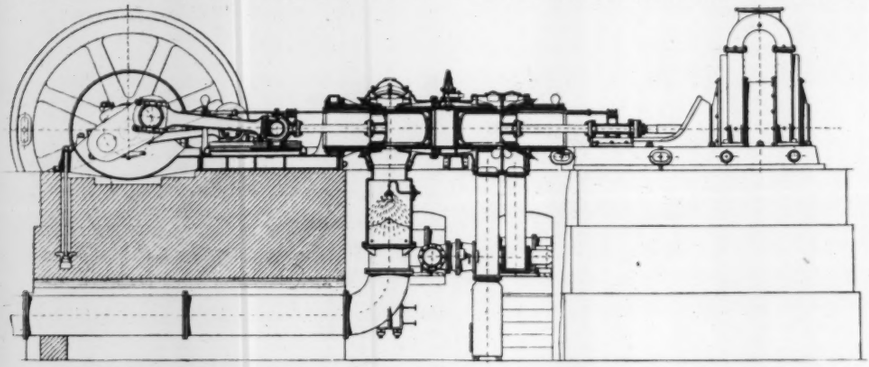


FIG. 15. LONGITUDINAL SECTION OF OECHELHAEUSER ENGINE.

CONTROL.—The lift of the valves, which is usually effected in the old engines by simple movements of levers at one end of which a cam acts upon a roller, has also undergone some alterations. In large engines this has been replaced by eccentrics and "roller-path" levers, thus imitating what is applied to steam engines of the Sulzer type. Fig. 5 shows an application of this kind adopted by the Winterthur Co. Some special valve gears have even been provided with ratchet movements with air pistons, such as Cockerill's and Nürnberg's.

The main object of these improvements has been to secure a more gentle and silent action relative to the size and weight of the parts to be actuated.

It is advisable to bear in mind with regard to English and American engines that the compression generally adopted for large gas engines is from 170 to 200 lbs. per sq. in.

COOLING.—Cooling is one of the points which has most attracted the attention of makers of large gas engines, as the effects of tension in the castings, due to unequal expansion, play a considerable part in the heavy pieces which enter into their construction. Cylinder heads or explosion chambers have been, in fact, one of the principal sources of difficulties and disappointment, as without any apparent reason they fracture at the most unexpected places. It is only long experience, assisted by numerous examples, which has placed makers on the track of the most appropriate forms for securing the strength of cylinder heads, rather than the selection of the materials to be employed in their construction. Steel itself has been tried without success. The principal factor in the preservation of cylinder heads is the manner in which the cooling water circulates therein, and the type which appears to be favored at the present time for Otto engines is the one which places the inlet and exhaust valves in the same vertical axis. Both are placed in a passage or ante-chamber surrounded on all sides by the cooling water. In order to secure for the whole of the parts an equal expansion this chamber is arranged symmetrically relatively to the axis of the cylinder. The exhaust is allowed to discharge on the extension and is surrounded as completely as possible by water. An abundant circulation is thus provided around the seat and the stem of the exhaust valve, which is also provided with an internal circulation in the case of engines of more than 60/100 HP. The water which has entered at the bottom of the cylinder head escapes at the top, or if need be in the case of engines of less than 75 HP. completes its circulation in the jacket of the cylinder proper, Fig. 6. It will be noticed on this occasion that this jacket is cast with the frame, and that the cylinder itself is independent, and free to expand, while the cylinder head is attached by flanges and bolts. This arrangement is the only one which secures a large base for the engine, and avoids the overhanging cylinder, which is completely banished from modern construction.

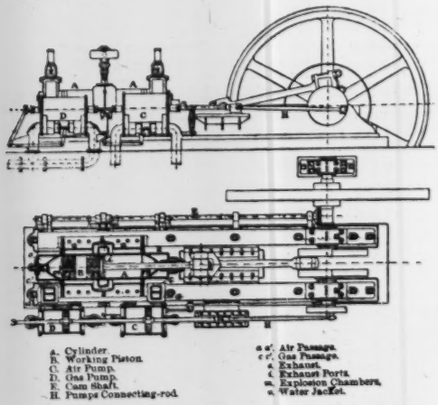


Fig. 17. Elevation and Sectional Plan of Double-Acting 2-Cycle Type Gas Engine. (Koerting)

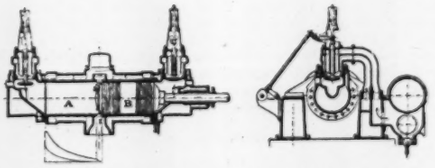


Fig. 18. Vertical Sections of Double-Acting 2-Cycle Type Gas Engine. (Koerting.)

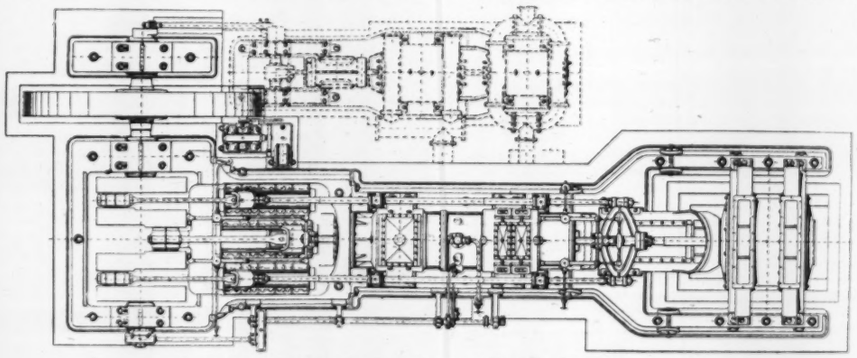


FIG. 16. PLAN OF OECHELHAEUSER ENGINE.

In order to combat the excessive temperature which attends high compression, certain makers, among whom we may mention the Nürnberger Maschinenbau Co., have even provided the piston ends of their single-acting engines with a water circulation. This is effected by a pump forming part of the engine, Fig. 7. This is evidently a complication which others have easily avoided for engines even of 150 HP., by arranging the piston so that a free access of air, due to the to and fro movement, alone effects the cooling. In order to derive every economical advantage from high compression without running the risk of self-ignition, the firm of Koerting has even arranged inside the explosion chamber of their Otto cycle engines a hollow casting through which there is a special water circulation, Fig. 8. This cooling effected in the very heart of the mixture deals with the excessive temperature there, and is said to have given the best economical results. In double-acting engines the cooling is still the object of great attention, and apart from the cylindrical jacket and cylinder ends, independent water circulation is used to cool the piston and piston rods, the seats of the exhaust valves, and the stuffing boxes, Fig. 9. The general temperature of the surrounding parts is cooler than in English engines, and for this purpose water is delivered at certain parts, such as the piston and piston rods, at pressures from 1 to 4 atmospheres (15 to 60 lbs.) by means of a special pump.

It appears from several experiments which the author has made on double-acting Otto cycle engines that the quantity of circulation water required for the different parts is as follows:

Per B.HP.-hour for engines of 200 to 1,000 HP.	Liters.	Gallons.
Cylinders, cylinder ends and stuffing boxes	18 to 24	4 to 5¼
Pistons, piston rods	8 to 12	1¾ to 2¾
Valve boxes and seats, and exhaust valves	4 to 6	⅞ to 1⅜
Or a total of	30 to 42	6⅝ to 9¼

These figures imply water admitted on an average of 12°—15° C. (53.6°—59° F.) and leaving the cylinder jackets at 25°—35° C. (77°—95° F.) the pistons at 35°—40° C. (95°—104° F.) and the valve seats and boxes at 45° C. (113° F.) on an average. An engine of 1,000 HP., of two-cylinder double-acting type, would therefore require about 40 cubic meters (8,900 gallons) of cooling water per hour. As this is an excessive quantity which is not available at every works recourse is commonly had to the use of cooling towers which reduce the consumption of water to about 0.5 liter (1-9 gallon) per HP.-hour, absorbed by evaporation. This method has also the appreciable advantage over the ordinary water circulation of eliminating, owing to the continuous use of the same water, the deposit of calcareous incrustations. Without possessing in the case of gas engine the same dangers as in steam boilers, lime scale and deposits still constitute a drawback. They obstruct the pipes and passages, and impede the regular cooling by coating (with a non-conducting material) the metal at the places where a high temperature is most injurious. At the parts cast with a double jacket, and which cannot be dismantled, it is necessary to arrange large openings covered by bolted lids in order to enable free access to the inside to remove these deposits.

IGNITION.—This question has for some years been solved in a satisfactory manner by the use of magnetos producing a spark on the break of the circuit which in a short time has ousted all the old method of ignition, such as the incandescent tube, the spark produced by batteries and accumulators, by dynamos, etc. This modern magneto ignition has for three years been provided with a timing gear, by means of which the ignition can be advanced or retarded experimentally during work. Still, as all working parts subject to the frequent and abrupt movements of the current breaker of the magneto are liable to get out of order and to wear rapidly, it is necessary to meet these objections by the adoption of very light parts with but little inertia. They must be easy of access and to handle for upkeep and inspection. With the increase in dimensions of engines it has been necessary to deal with greater volumes of explosive mixtures but of poorer composition. This has wisely led many makers to provide their double-acting engines with two distinct ignitions for each piston face, the one placed near the inlet valve at the top and the other at the bottom near the exhaust valves.

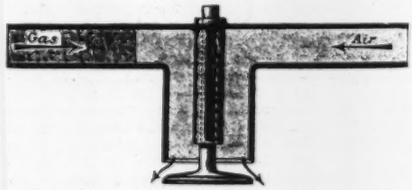


Fig. 19. Admission-Valve admitting Air before Mixture, 2-Cycle Engine. (Koerting.)

STARTING.—A few words remain to be said on the starting of large engines to which the explosion "self-starter" has not been applicable. The apparatus, which causes behind the piston the explosion of a mixture previously introduced into the cylinder when the engine is stopped, develops a too sudden and violent strain, owing to the resistance of the inertia of the parts at rest. Moreover the action of this apparatus is too precarious. Use is therefore made of air compressed to 150 to 225 lbs. by a compressor and stored in a reservoir. When an engine has to be started, the crank is placed in the starting position corresponding to the explosion stroke by turning the fly-wheel by means of a lever or a system of gearing. In the case of the single-acting engines a charge of compressed air is introduced by operating by hand the valve shown at the end of the cylinder head of the engine of Fig. 6. This operation is repeated several times in succession until the engine, sufficiently started, draws in

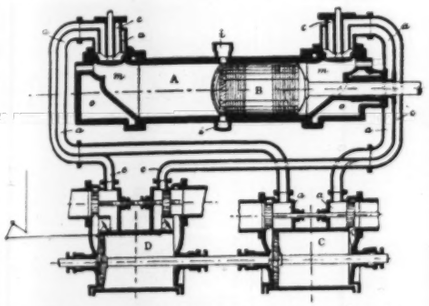


Fig. 20. Pumps Regulating Inlet-Valve, Koerting Engine.

the explosive charge and drives itself. In the best double-acting engines the starting valve working by compressed air is generally operated mechanically by the half-speed shaft.

LUBRICATION.—Lubrication has also of late formed the subject of important improvements. In engines of medium power, i. e., up to 150 to 200 HP., the main bearings of the crank shaft are usually lubricated by means of a revolving ring plunging in an oil bath. For larger engines bearings with brasses consisting of several parts, to take up the wear and the working stresses, are used. As this system renders it impossible to apply the lubricating ring which gives such good results in dynamos, recourse has been had to continuous oil feed under pressure. This pressure also secures a more reliable lubrication of large surfaces supporting great loads, as is the case with the crank shafts of engines of 1,500 to 3,000 HP. which exceed 500 m.m. (1 ft. 7 11-16 ins.) diameter. For lubrication the pistons and the stuffing boxes of the piston rods, oil feed under pressure is a necessity, as the oil is more reliably conveyed to the rings, the tightness of which depends to a great extent on the free play secured to them by proper lubrication. Excess of oil in the cylinders which, by rendering them dirty, is the principal cause of "back firing"; this has also been greatly reduced by the use of a draining device to the cylinder. Fig. 6 represents a valve which is fitted for this purpose at the back lower part of the cylinder. It is operated by hand, and enables surplus oil or foreign matters to be expelled while the engine is working.

The following formula enables us to determine the dimensions to be given to the fly-wheels of different types of engines, having regard to the purposes for which they are intended:

$$P D^2 = K \frac{N}{a n^3}$$

hence

$$P = K \frac{N}{D^2 a n^3}$$

in which

P = the weight of the rim (without arms or boss) in tons
D = diameter of the center of gravity of the rim in meters
a = the degree of irregularity
n = the number of revolutions per minute
N = the number of brake-HP.
K = coefficient varying with the type of engine

I. K = 44.000 for Otto cycle engines, single cylinder, single-acting
II. K = 28.000 for Otto cycle engines, two opposite cylinders, single-acting, or one cylinder double-acting
III. K = 25.000 for two cylinders, single-acting, with cranks set at 90°
IV. K = 21.000 for two twin cylinders, single-acting
V. K = 7.000 for four twin opposite cylinders, or for two tandem cylinders, double-acting

The total weight of the fly-wheel is P x 1,4

Fig. 10 is a diagram showing the arrangement of cylinders.

CONSUMPTION AND EFFICIENCY.—Modern large engines have attained high organic efficiency owing to the proportional reduction of their weight and the finish of their construction. Double-acting engines are usually made with a weight of at least 100 kgs. per HP. (220½ lbs.). It is admitted that Otto cycle double-acting engines attain 90 to 92% mechanical efficiency, whereas an output of only 75 to 80% was attained by 2-cycle engines. This waste, being due to the work absorbed by the air pump and by the gas pump, cannot, however, deteriorate the value of the magnificent engines, of which the Oechelhäuser and the Koerting are classical types possessing their own advantages. Double-acting Otto cycle engines attain a thermal efficiency of 28 to 30% relatively to the effective work, i. e., the HP.-hour is attained with about 2,200 calories (8,729 B. T. U.). This consumption converted into the volume of the different gases used industrially would be as follows:

Coke oven gas 585 liters (20.7 cu. ft.).
Mond producer gas 1,760 liters (62.2 cu. ft.).
Anthracite producer gas 1,850 liters (65.4 cu. ft.).
Blast furnace gas 2,500 liters (88.3 cu. ft.).

This implies the mean chemical compositions and the average calorific values indicated on the synoptic drawings of the table of Fig. 11, which shows the normal content of each gas in hydrocarbons (C_nH_n), marsh gas (CH_4), carbon monoxide (CO), hydrogen (H), carbonic acid (CO_2) and nitrogen (N).

The author will now examine in their main features the improvements in the construction of large engines during the last three or four years. In order to proceed chronologically, he will analyze simultaneously the present engines of the Oechelhäuser and Koerting 2-cycle type, and the double-acting Otto cycle engines of the Deutz, Cockerill, Nürnberg, etc., types. Among the numerous systems of gas engines designed for the utilization of the waste gases of blast furnaces and producer gas may be mentioned the remarkable 2-cycle engines designed by Mr. von Oechelhäuser.

OECHELHAUSER ENGINE.—This system was one of the first to be applied to high power engines. It was put into practice in the early part of 1898 in the shape of a 600-HP. engine, and on that occasion disclosed its excellent qualities which have continued throughout a period of seven years' work. The main feature of the system consists in the employment of two trunk pistons working in a single cylinder, and thus reminds us of the device already applied for a certain number of years by Robson and made by Scott Brothers, of Halifax, England. This engine was of the Otto type with distribution by valves, while the von Oechelhäuser engine is of the 2-cycle type, and the distribution is effected without the intervention of valves applied to the cylinder. This feature is the more interesting since, in large engines especially, the valves constitute delicate organs of difficult upkeep, having regard to the high temperatures to which they are subject in the explosion chambers. The diagram, Fig. 12, shows the mode of working the two single-acting pistons. The front one is attached by a connecting-rod to the center crank of a triple crank shaft and works by thrust, at the time of the working explosion, while the back pis-

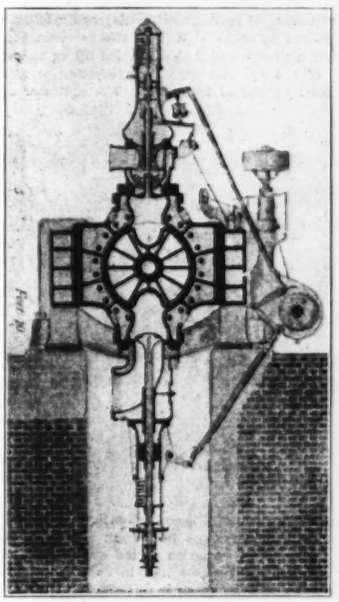


Fig. 21. Cross Section of Cylinder, Showing Valve Gear, Cockerill Engine.

ton is attached by a system of swing-bar and counter-rods to the side cranks and works by pulling at the time of the explosion. The first advantage of this arrangement is the attainment of perfect balancing of the working parts, and particularly of the crank shaft, with regard to which the driving efforts neutralize the reactions at the bearings. Again, the explosion chamber is formed by the cylinder itself and the ends of the pistons when the latter approach each other at the time of the ignition of the gaseous mixture. This explosion chamber thus forms a chamber presenting the minimum of surface cooled by water circulation and free from passages and recesses which on the ignition of the explosive mixture impede the movement of the pistons. These devices should have a manifest influence on the thermal output of the von Oechelhäuser engine. The distribution is secured by the pistons themselves forming slide valves, which uncover and in their movement again cover the ports provided in the cylinder for the admission of air and gas and the discharge of the products of combustion.

Fig. 12 shows a diagrammatic section of the engine through the cylinder and the feed pump. The openings in the sides of the cylinder serve for the exhaust, a the admission of air, and the admission of gas. Before the pistons attain their dead center or outer end of stroke, the front piston uncovers the exhaust port e, then the back piston uncovers the air inlet ports a, and the air, thus entering under pressure, sweeps the cylinder before it has uncovered the ports g admitting the gas, which then mixes with the air to form the mixture. The pistons then return inwards, and as soon as they have again cov-

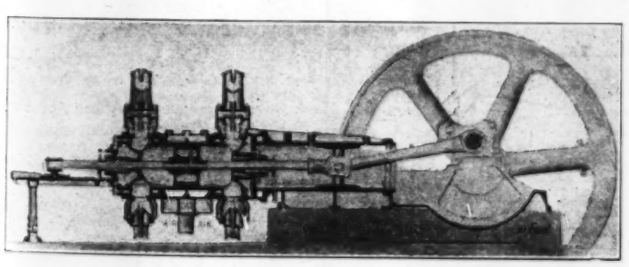


FIG. 22. 300-HP. DOUBLE-ACTING ENGINE. (OTTO-DEUTZ.)

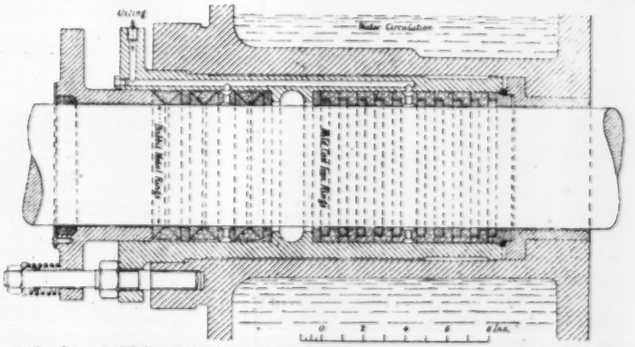


FIG. 23. PISTON-ROD STUFFING-BOX, 300-HP. DOUBLE-ACTING ENGINE. (OTTO-DEUTZ.)

FLY-WHEELS.—The mode of regulation by admission on each cycle enables fly-wheels relatively less heavy to be used. The same may be said of the application of double-acting, and of multiple cylinders. The requirements, however, which are now expected from engines in large electric light stations have given rise to the use of special fly-wheels, with the object of reducing as much as possible the degree of cyclic irregularity. For ordinary industrial purposes a regularity of 1/25 to 1/30 of the speed in one and the same cycle can readily be attained. For electric lighting by continuous current dynamos it is necessary, with the view of obtaining a steady light, for the degree of irregularity to be less than 1/50 or 1/60, while for the working of alternating-current generators in parallel it should practically be about 1/150.

ered the openings which we have described compress the charge in order to commence the operation anew. This therefore comprises two principal strokes—compression and expansion. The other operations, which consist of admission and exhaust, and correspond to one revolution in the Otto cycle engines, only occur in this case during a fraction of the cycle, owing to the fact that the gas and the air are introduced under pressure.

The double-acting pump p whose piston is fitted on the extension of the back piston of the engine supplies it with air and gas, respectively, through the passages a^1 and g^1, terminating at the front face and at the back face of the pump piston c. The distribution is regulated in such a way that the passages a^1 and g^1 always contain air and gas under a pressure of 5 to 6 lbs. for filling the working volume of the cylinder which corresponds to about 0.7 of the total volume of the pump. The indicator diagram

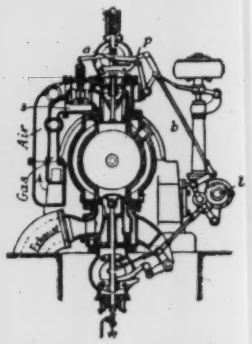


Fig. 24. Cylinder and Valve-Gear. (Otto-Deutz.)

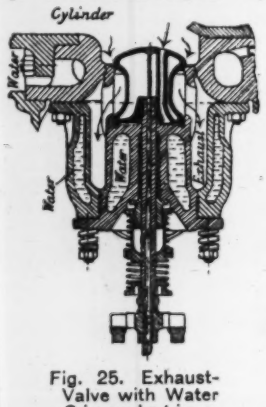


Fig. 25. Exhaust-Valve with Water Circulation. (Otto-Deutz.)

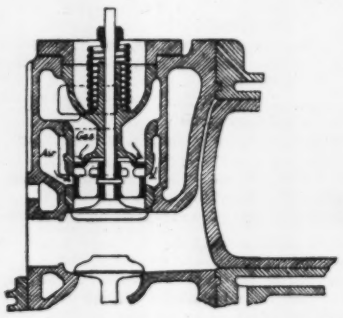


Fig. 26. Circular Slide-Valve Fixed to Stem of Inlet-Valve. (Nuernberg.)

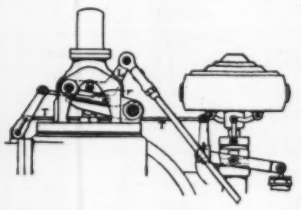


Fig. 27. Governor Acting on Stroke of Inlet-Valve. (Nuernberg.)

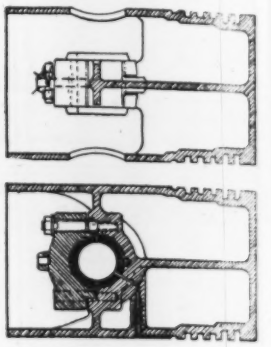


Fig. 28. Piston, Nuernberg Engine.

thus takes the form of Fig. 13, showing the exhaust, the air scavenging and the gas inlet from a to b. The regulation is effected by variation of the quantity of mixture. The compression is variable, but in order not to produce a vacuum the entire charge is introduced in the cylinder. The governor then controls the opening of a return valve which enables a part of the mixture admitted to be returned to and stored in the piping.

Fig. 14 shows a section across the distribution; Fig. 15 a longitudinal section, and Fig. 16 a plan. The two latter represent an engine with blowing apparatus (on the right) for blast furnace. The gas and air pump is shown in a dotted line under the surface, on the horizontal view. The von Oechelhäuser engines have been made since 1899 by the Deutsche Kraftgas Gesellschaft. Several important firms are making them under license or for their own account after having acquired the patents. Thus some 60 of these engines, representing a total power of 50,300 HP., have found their way into different countries and particularly for use in metallurgical establishments.

KOERTING ENGINES.—Messrs. Koerting Brothers, of Hanover, have made gas engines since 1881 and producers

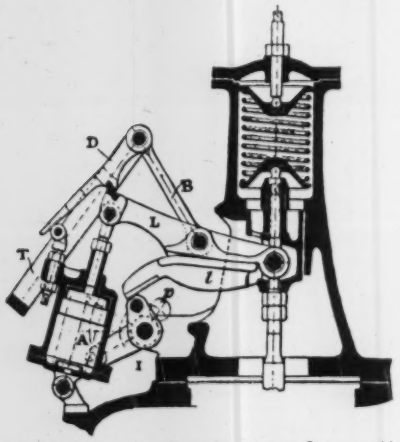


Fig. 29. Automatic Cut-off Valve-Gear. (Nuernberg.)

since 1889. Up to 1896 this firm had turned out about 3,500 engines, representing 15,000 HP. Since that time the Koerting Works, now carried on under the name of Koerting Brothers, Limited, has produced 4,200 new engines. In recent years in particular 50,000 HP. in two-cycle engines of their special type have been supplied. Side by side with the construction of the two-cycle engines the construction of the four-cycle type has developed, and the sale has attained 100,000 HP., while at the present time engines are under construction representing several thousands of horse-power. The Otto cycle engines are all provided with the Koerting valve gear previously described, with the special mixing valve regulating the simultaneous passage of air and gas, and contributing to their homogeneous mixture before admission into the cylinder. This valve is automatic and is lifted by the suction action of the piston only, falling back by its own weight as soon as the suction ceases, i. e., as soon as the inlet valve closes through the compression.

The Koerting Co. makes Otto cycle engines of the single-acting type in some 15 sizes, from 10 to 175 HP., the latter type having a diameter of 630 mm. (24.8 ins.) with a piston stroke of 1.020 mm. (40.16 ins.) and performing 135 revolutions. The 60 to 125-HP. engines are provided with the cooling device shown in Fig. 8. The Koerting Company makes on the same system, but with two twin cylinders, a 200-HP. engine, being 490 mm. (19.29 ins.) in diameter, by 800 mm. (31.5 ins.) stroke, running at 160 revolutions per minute. It will be seen that these dimensions are amply large, inasmuch as they effect the work specified with a mean pressure of 4.6 to 4.7 kgs. per sq. cm. (65.4 to 66.8 lbs. per sq. in.) on the piston even if a mechanical efficiency of 80% only is considered. As a matter of fact single-acting Koerting engines usually exceed that output. Above 250 HP., the Koerting Co. applies its double-acting 2-cycle type, which is used both with producer gas, with blast-furnace and with coke-oven gas.

These types being doubled enable twice the power to be obtained, and if necessary an engine of 3,000 HP. with two cylinders each of 1,500 HP., with a common shaft and fly-wheel only. In this engine the work is effected in the same manner on the two sides of the piston, which is supported by rods working in stuffing boxes. The double-acting 2-cycle engine is represented in elevation and in horizontal and vertical sections in Figs. 17 and 18. Its action is as follows:

(1) The ignition of the mixture and the development of the motive pressure take place after the introduction of the charge and quite close to the back dead center of the piston.

(2) The expansion of the ignited mixture and the transmission of the power to the crank shaft take place during the forward motion of the piston.

(3) When the piston has reached its front dead center, the expulsion of the products of combustion and the admission of the new mixture take place.

(4) During the backward stroke of the piston the latter produces the compression of the explosive mixture.

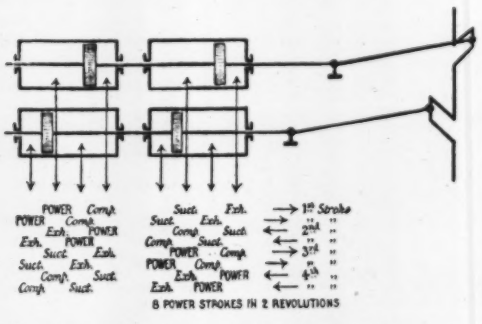


Fig. 30. Diagram Showing Succession of Strokes. (Nuernberg.)

This work, which is accomplished in the Otto cycle single-acting engines during four strokes of the piston, is effected in the Koerting engines in two strokes, the expulsion of the residuum of the combustion, and the intake of the new charge being effected during the very short time in which the piston is in the vicinity of the front dead center. The working piston B does not effect the suction of the mixture; the latter is delivered to the cylinder A by pumps D and C, and the new charge itself expelling the products of combustion which it afterwards replaces.

The introduction of the new mixture therefore takes place in the following way.

(1) It distributes itself at once over the whole section of the cylinder, and thus drives out uniformly the old mixture

(2) A stratum of neutral gas interposes itself between the new mixture and the hot residuum of the preceding explosion, preventing the contact of the two mixtures and premature ignition of the new charge.

The exhaust ports i of the products of combustion are placed in the center of the cylinder and form annular orifices; the piston, of a length equal to its stroke, less the width of the exhaust openings (1-10th of the stroke) itself closes these openings alternately to the back and front ends of the cylinder. The exhaust of the products of combustion and the introduction of the new charge expelling the last traces of gas of the previous explosion, take place in a time equal to that of the opening and the closing of the ports by the piston. The inlet valves, which are of the flat type, closing by a spring, are operated by cams and are situated one at each end of the cylinder. Gas and air are supplied by separate pumps D and C; the mixture takes place at the entrance to the cylinder only. These pumps in the first instance deliver pure air to the cylinder and then a mixture of uniform composition, the quantity of which alone varies, to regulate the power of the engine. The pumps introduce the mixture at a pressure of about 15 lbs. Their pistons are therefore at the end of the stroke as soon as the engine piston has again covered the exhaust openings, and the compression of the mixture commences. The pistons of the two pumps are on the same rod, they have the same movement, and the composition of the mixture depends on the relation between the two pistons only.

The air passages aa' and gas passages cc' terminate at the inlet valve. It follows that, on the opening of this valve, the fluid which is nearest it will enter first into the engine cylinder. If then by a device of some kind air can be passed into the gas passage driving out the gas, air will then be on both sides of the valve, as shown in Fig. 19 it is certain that on the opening of the valve it will first cause pure air to pass into the cylinder until gas has reached the valve. Taking into account this material point, it is easily understood how the pumps act in order to introduce the charge and regulate it, Fig. 20. As we have already said they draw and deliver at the

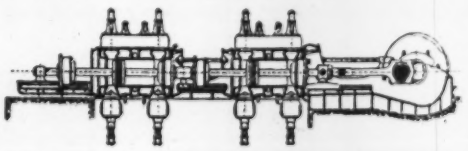


Fig. 31. Back Covers Removed to Afford Access to Valves. (Nuernberg.)

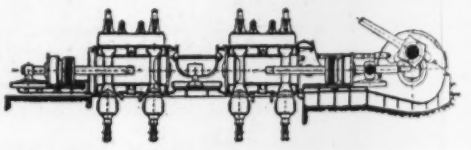


Fig. 32. Pistons Removed. (Nuernberg.)

same time. What has to be done is first to introduce pure air and then an intimate mixture always of equal composition; the gas pump should work without delivering gas for a certain time during which the air pump is at work. The gas pump afterwards supplies the gas, so that a mixture of the desired composition reaches the engine in the place of pure air. The air pump acts as a steam engine with full admission. In the gas pump the closing of the suction takes place after the piston has performed 40 to 50% of its stroke only. During this period the delivery remains closed, and the gas, drawn in during the preceding stroke, re-enters the suction pipe.

During the second period of the piston stroke, the pump delivers the gas, and from that time the two pumps de-

lixes together gas and air with the same speed per unit of time, so that the composition of the mixture remains the same. The inlet valve of the engine is not open at the commencement of the delivery stroke of the piston of the air pump, it opens only after the pump piston has performed about half its stroke. During this time air accumulates in the passage and, in consequence of its pressure, passes into the gas passage forcing back the gas as the gas pump is not at this time delivering. Pure air only therefore enters into the cylinder on the opening of the inlet valve until the gas pump begins to deliver. In this way the cylinder is scavenged, and an insulating stratum formed before introducing the explosive mixture, which is always of a uniform composition.

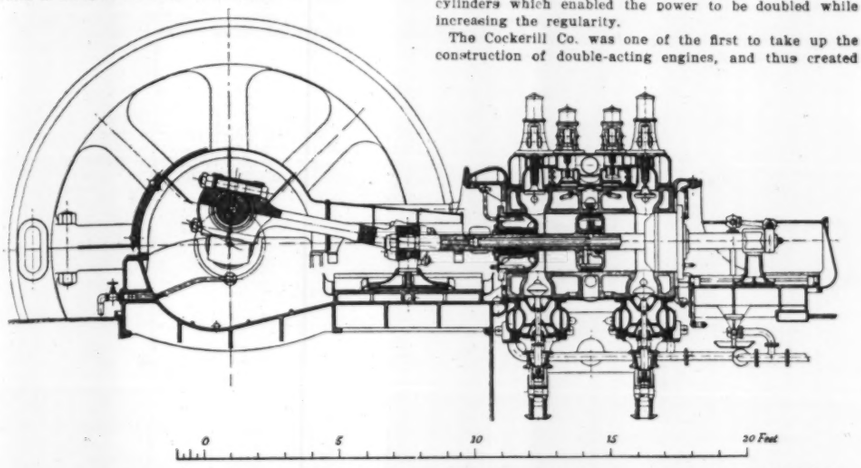


FIG. 33. SINGLE-CYLINDER ENGINE, SHOWING SECTION THROUGH VALVES. (NUERNBERG.)

The regulation of the engine is obtained by two means: (1) By retarding the delivery of the gas pump. This retardation is obtained by operating the slide valve of the pump by a link operated by two different eccentrics. The link being shifted by the action of the governor which raises and lowers it. This mode of regulation requires the use of a very heavy governor.

(2) By establishing a passage (communication) between the delivery and suction of the gas pump. This passage is provided with a throttle valve (butterfly) actuated by the governor. When this valve is partly open a more or less large quantity of gas repasses during the suction period and during the first period of the return of the piston, from the delivery passage to the suction chamber. The gas column recedes into the passage, near the inlet valve and is replaced by air. On the opening of the inlet valve a quantity so much the richer in air and the weaker in gas enters the cylinder, according to the opening of the valve. The regulation is effected, as in the first case, by means of a link. The ignition of the mixture is effected electrically by means of two magnetos. For starting the engine compressed air is used.

It is the Koerting Co. which has so far made the most important installations and they necessarily consist of double-acting engines. Mention may be made of the power station of 5,500 HP. of the Gutehoffnungshutte establishments at Oberhausen (Rheinland) equipped with seven engines, four of which are 1,000 HP. and three of 500 HP. The Koerting engines were the first explosion engines used in America for the utilization of blast-furnace gas, which innovation was the more remarkable as it involved, at the outset, a total power of 42,000 HP. It was carried out by the De la Vergne Refrigerating Machine Company of New York for the Lackawanna Iron & Steel Co. of Buffalo (N. Y.), and consists of ten coupled dynamos and two-cylinder engines of 1,000 HP. each, for electrical service; and sixteen engines of the same power which drive from their crank-shaft blowing engines for the blast furnaces. This installation constitutes up to the present the most important power house in the world.

Several important installations have also been made for the utilization of lignite, which is very abundant in many parts of Europe and America. This lignite is treated by special producers supplying gas under pressure. An electric station installed at Julienhutte in Germany, and driven by coke-oven gas, consists of three Otto-cycle engines, single acting, of which three of 300 HP. are of the twin type with fly-wheel dynamo, and one is a single cylinder of 125 HP. with dynamo on the crank shaft. The latest important installations of Koerting's 2-cycle engines have been undertaken by the parent company of Hanover, and consist of 104 engines developing in all 89,125 HP.

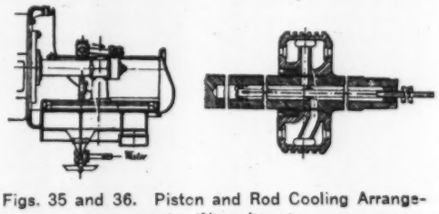
COCKERILL ENGINES.—Mention has been made of the successful trials of the Cockerill Co., which, as far back as 1894, made its first experiments on a small engine driven by gas from its blast furnaces. Four years later this firm constructed from the details furnished by the late scientist Delamare-Debouteville the 200 HP. engine which at the present time is still driving an alternating current dynamo for the production of motive power. Then came the famous engine of 600 HP. single acting, which drives a blowing apparatus for the blast furnaces delivering 500 cubic metres of air at a pressure of 40 centimetres mercury (15¾ ins.) This engine, started in 1900, formed the subject of memorable experiments undertaken under the direction of Prof. Hubert, with the collaboration of some experts, such as our friends Aimé Witz and the late Bryan Donkin. In order to increase the power of the engines without adding to the dimensions already involved by a piston of 1.3m. (51 ins.) diameter × 1.4 (55¼ ins.) stroke, the technical department of the Cockerill Co. then designed an engine with tandem cylinders which enabled the power to be doubled while increasing the regularity.

The Cockerill Co. was one of the first to take up the construction of double-acting engines, and thus created at the end of 1901 its first single cylinder Otto-cycle engine of 1,200 HP. for the blast furnaces of their own works. The construction of double-acting engines has become common, and they have replaced the single-acting type, which is now only constructed in exceptional cases. Before arriving at their present type the Cockerill Co. created quite a series of engines, all of which are remarkable for a manifest tendency to depart from common principles in order to attain original forms and devices of real interest. As makers of machinery for the iron industry the Cockerill Co. is, in fact, in a better position than most people to appreciate the many requirements to be satisfied by engines suitable for this industry.

One of the latest types of single-cylinder double-acting engines driving a "Southwark" blowing engine has the following dimensions:

Diameter of the engine piston... 1.300 m. (4 ft. 3 3-16 ins.)
Diameter of the blower piston.. 2.250 m. (7 ft. 4½ ins.)
Stroke of the pistons..... 1.400 m. (4 ft. 7⅛ ins.)

This blowing engine has to furnish air at a pressure of 0.6 m. (23.6 ins.) mercury, and develop at 80 revolutions per minute 1,200 HP. The engines present a characteristic aspect, and careful investigation of the tensile strains and other stresses to which the different parts are subject have given rise to the creation of special forms peculiar to the Cockerill engine. The strength and simplicity of the engine have thereby been improved, but the neat appearance to which we are accustomed has perhaps lost something. Still commercial considerations are the most important. The frame consists of two strong cast iron girders which extend the whole length of the engine between which the cylinders are placed, and which are terminated by the cross-head guides and the bearings of the crank shaft. The cylinders, by reason of their being fixed by bolts and keys, are independent of the frame. They are cast with their jacket and connections for the inlet valves at the top and exhaust valves at the bottom.



Figs. 35 and 36. Piston and Rod Cooling Arrangement. (Nuernberg.)

The piston consists of two parts bolted and secured to the rod by collars, thus dispensing with screwing, which is unsuitable for transmitting great strains. As in the case of all double-acting engines the piston is cooled by a circulation of water under pressure passing through the rods. Apart from the cylinder jacket, the ends are provided with a water circulation, also are the valve chests (boxes), as well as the brasses of the crank shaft and the crosshead guides. The regulation is effected in two ways, according to the type and the application of the engine. For high-speed engines, where the masses in movement are considerable and for which great regularity is required, a high compression is necessary to assist in giving uniformity. In this case the regulation is effected by varying the composition of the mixture and in keeping the air supply constant. The total volume being invariable the compression likewise remains constant. The valve gear is shown on Fig. 21, in a cross section of the cylinder.

In the case of engines working with less speed and whose variable revolutions, as in the case of those driving blowing engines, which contribute to the balancing of the working parts of the engine, regulation by variable admission of variable quantity of charges of uniform composition is used. As a consequence the compression varies. In both cases the valves are operated by cams and springs. The inlet valves are returned to their seat by a ratchet movement with air-pump, Fig. 21. The types constructed by the Cockerill Co. are divided into—(1) Single-cylinder engines, (2) engines with two twin cylinders, (3) engines with two cylinders tandem, (4) engines with four cylinders twin tandem.

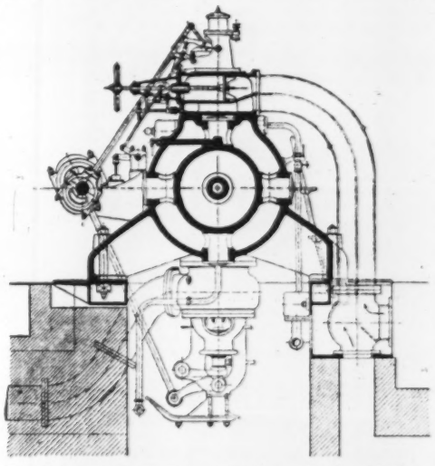


Fig. 34. Single-Cylinder Engine, Cross Section through Gas and Air Inlet Piping. (Nuernberg.)

These types can be seen from Fig. 10 showing the diagram of the arrangement. The two kinds of regulation are applicable, according to each case, to the different types enumerated. The double-acting single-cylinder engines are made up to 1,500 HP., but their co-efficient of cyclic irregularity with standard fly-wheels is fairly high, so that this type of engine is rarely used except for driving blowing apparatus or other work not requiring absolute regularity. With their engine of the 4-cylinder twin tandem type, double acting, the Cockerill Co. can obtain a prime mover of 5,000 to 6,000 HP.

The total number of engines constructed up to the present by the Cockerill Co. and their concessionaires has reached 148, representing in all 102,925 HP. or an average power per engine of about 695 HP.

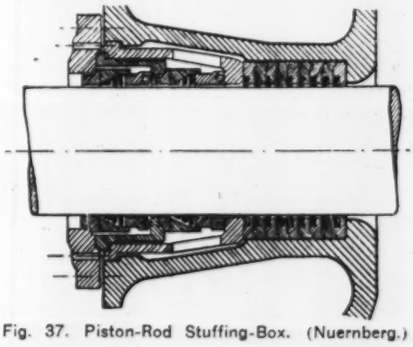


Fig. 37. Piston-Rod Stuffing-Box. (Nuernberg.)

The purposes for which they are employed are approximately the following: Electrical purposes, 45%; blast furnace blowers, 52%; rolling mill, 2%; various purposes, 1%.

OTTO-DEUTZ ENGINES.—The brilliant record of the Deutz Gas-Engine Works is well known, which, continuing the traditions of its illustrious founders, Messrs. Otto and Langen, has for 40 years constructed the four-cycle engines, bearing the name of the inventor. Since its formation this company has turned out nearly 70,000 engines. It necessarily commenced with the small single-cylinder horizontal and vertical engines, since 1895 it has been engaged in the construction of high power blast-furnace single-acting engines attaining with one, two and

four cylinders, twin or double-twin, powers of 125 HP., 500 HP., 1,000 HP. and upwards. A large number of these engines were in a short time working in industrial establishments with generator gas, blast-furnace gas or coke-oven gas, while others took the place of steam engines in water-works and electric stations for towns, etc.

The 1,200 HP. 4-cylinder engine, exhibited at Dusseldorf in 1902, won the admiration of experts as being a type of the most powerful engine of the time in Germany. It

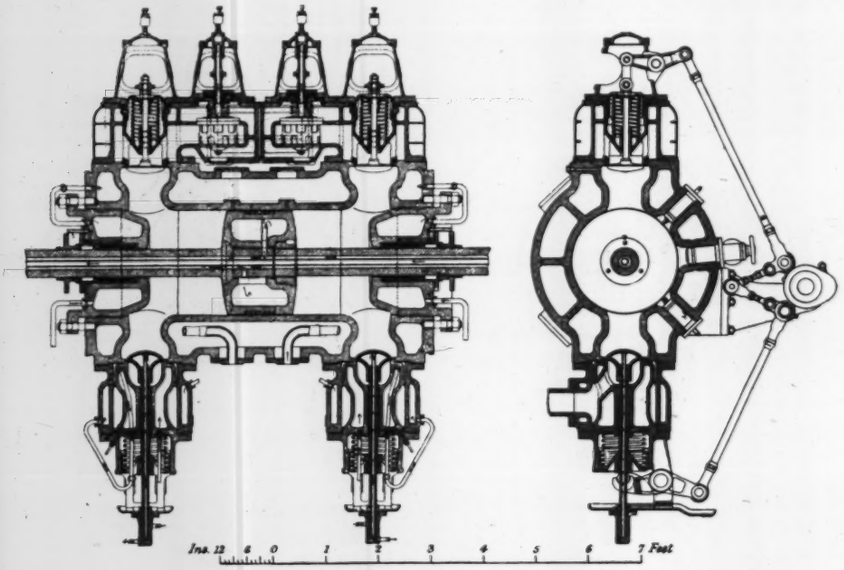


FIG. 38. 700-HP. TANDEM ENGINE, LONGITUDINAL AND CROSS SECTIONS THROUGH INLET VALVE. (EHRHARDT AND SEHMER.)

was constructed for the "Gutehoffnungshütte" for driving a blast furnace blower to furnish 1,000 cubic meters (35,316.6 cu ft.) of air per hour at a pressure of 0.5 atm. (7.4 lbs.) The total weight of this engine was 219 tons, the fly-wheel accounting for 19 tons. This weight is manifestly stupendous compared with the weight of steam engines with which poor-gas engines have to compete. These large engines, constructed according to the single-acting type, thus attained the excessive weight of 180 kgs. (396.8 lbs.) per horse-power. Their price was necessarily high and the space occupied excessive. It was therefore necessary to find a solution of this difficulty in order not to impede the development of large engines. Such a solution is found in the double-acting engine which is now the current type of the Deutz Works. Reference will be made to this engine later, and in the meantime the author will examine the characteristics of the small engines now made by this firm.

The single-acting type has been retained, and for about 2 years the makers have been working for the unification of the system of valve gear. The system shown by Fig. 4 is now applied to all sizes, except for engines of 120 to 150 HP. per cylinder, in which they fit the mixing valve and the gas valve separately, with the object of facilitating access to the latter for the purpose of cleaning. This device is again met with in the large double-acting engines described later. In order to appreciate the simplicity of the parts and arrangement of the new valve gear for admission in variable quantity of a charge of uniform composition, compared with the old system of variable mixture by conical cam, it is sufficient to refer to the new Otto type made not only in small sizes but up to to 250 HP. For powers of 200 to 300 HP. the old type of engine was constructed with twin cylinders, i. e., with two cylinders side by side or opposite that is with two cylinders one facing the other. The latter arrangement has, however, been abandoned by the principal

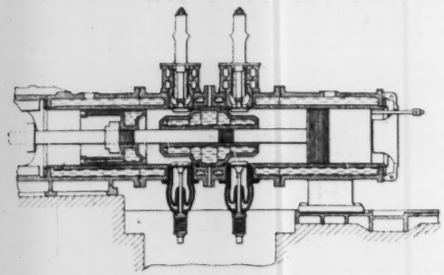


Fig. 40. Longitudinal Section, Dingler Gas Engine.

European firms, experience having shown that it is subject to considerable wear and tear. In fact, one of the pistons, in consequence of the reverse working, is subject to a reaction from the bottom to the top at the time of the explosion, which tends to lift the piston and produce shocks if there is the least play due to wear and tear. For powers of 400 to 1,000 HP., the arrangement of double twin opposite cylinders was adopted.

With regard to the form of the parts exposed to heat and the proper utilization of the explosive mixtures, the Otto Company has benefited from the long practice acquired in the construction of the different forms of cylinder heads for its single-acting engines, in designing the double-acting type, for which they have adopted the general arrangement and external form preferred for good modern steam engines. Since 1901, the Otto Company has engaged in the making of these double-acting engines and maintained its preference for the 4-cycle type, which is, moreover, the type most generally adopted nowadays by its competitors.

In 1902 this company started its first double-acting engine of 200 HP. at its own electric station, where it first did duty as an experimental engine and afterwards in the works. In the meantime 46 engines on this system, representing in all 31,500 HP., have been constructed by the Otto Co. at its Deutz Works and its concessionaires. Fig. 9 represents a 200 HP. engine and Fig. 22, a 300

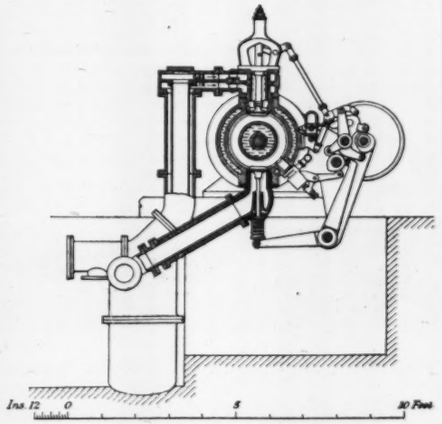


Fig. 41. Enlarged Section on A B, Fig. 40. (Dingler.)

HP. engine of the latest double-acting type, of which the principal dimensions are: diameter of piston 620 mm. (24.4 ins.); stroke of piston 780 mm. (30.7 ins.), at 130 revolutions per minute. The cylinder is constructed so as to allow for the independent expansion of the jacket and the liner. The latter is cast in one piece with the ends of the jacket, while the annular middle portion is connected and made tight by a flexible joint. The ease with which this part can be dismantled facilitates the thorough cleaning of the jacket. In the case of engines of the largest sizes the cylinder is even made in three parts, the ends of which carry the valve boxes. The latter in each case fitted in the same vertical axis, the inlet at the top and the exhaust valve at the bottom, in such a way that the surplus oil or moisture is driven The lower part is provided with water circulation fixed by bolts, with springs which enable them to slightly on expansion. The piston is supported by piston rods, without its weight resting on the bottom of the cylinder. The cooling-water inlet and outlet are ed through the rods being connected to a pump by articulated pipes.

The channel made in the piston rods contains, throughout its length, a tube having an inside partition opposite the piston block (head). The water is supplied to the piston along the passage concentric to the tube and leaves

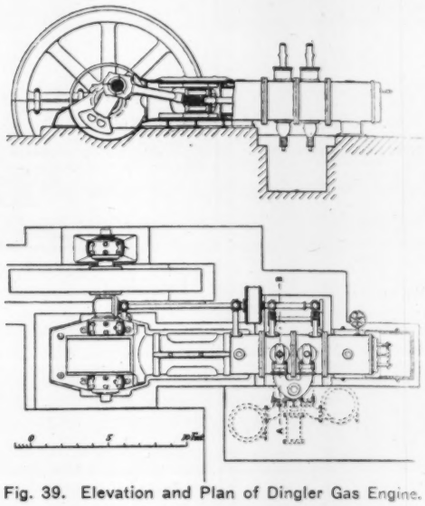


Fig. 39. Elevation and Plan of Dingler Gas Engine.

by the tube itself. The stuffing-box, being one of the delicate parts of the double-acting engines, has been the subject of special care. It will be seen from Fig. 23 that it consists of a movable casing fixed to the cylinder by an external flange. This casing is provided with a longitudinal oil-way. At its extremity, near the cylinder, is a chamber containing a series of collars carefully adjusted in the recesses of which the rings, of a special metal which bear on the rod are placed. In a second chamber there is a series of babbit metal collars of triangular section, forming a wedge when tightened up, an operation which is effected by means of the outer flanged sleeve forming a gland.

Fig. 42. View of Governor of Dingler Gas Engine.

Fig. 24 is a section across the cylinder showing the valve gear. The regulation is effected by acting on the quantity of charge admitted to the cylinder, as in the case of the single-acting engines, but with the difference that the charge is regulated by an auxiliary double-seat valve s whose lift is determined by the governor. This valve receives its movement from the lever operating the main inlet valve p which has a fixed lift. This lever has, as a fulcrum, a rolling path; it is jointed on the one hand with the stem of the inlet valve and on the

other hand to the oblique connecting rod b receiving its movement from a cam keyed on the side shaft 1 of the engine. The valve is depressed, i. e., opened by the operation which we have just described, and returned to its seat by the spring attached to its stem.

With regard to the regulating valve, the set of levers actuating it have a variable fulcrum, formed by roller a which is displaced to vary the lift of the valve. This roller, which is movable, is fitted at the end of a rod attached to the governor. In order to regulate in advance the composition of the mixture, the quantity of which admitted to the cylinder is determined by the governor, a cock has been fitted on the gas inlet pipe and a throttle on the air pipe. Both these are operated by hand. The exhaust valve is also operated by a connecting rod worked off the side shaft by a cam and a lever with

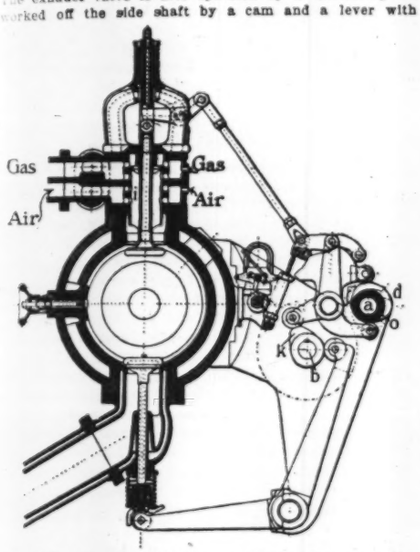


Fig. 43. Details of Governor, Dingler Gas Engine.

rolling path. It is provided with a water circulation which is operated through its stem as in the case of the piston rod. A water circulation is also set up in its box, which carries the seat of the exhaust valve. In the largest engines, such as the 2,000 HP., with 2 tandem cylinders, with a diameter of piston of 1,100 mm. (43.2 ins.) and 1,300 mm. (51.1 ins.) stroke, the exhaust valve has a seat of D = 380 mm. (14.9 ins.) which, on the exhaust, would have to overcome a pressure of about 2,000 kgs. (4,409 lbs.) when lifted. It has been constructed with 2 seats (Fig. 25) with a communicating passage which establishes the same pressure underneath as above the disk of the valve. The disk is therefore balanced and only offers to the lift the resistance of the reaction springs.

The ignition of the charge is effected by magneto electric apparatus, the starting is by no means of compressed air and the lubrication is under pressure as is also the water circulation for the piston, the stuffing boxes, etc.

The number of double-acting engines which the Deutz Works has supplied or has at present in course of execution amounts to 64, ranging in size from 200 to 2,000 HP., with an aggregate of 34,660 HP.

NEURNBERG ENGINES.—The "Vereinigte Maschinen Fabrik Augaburg and Maschinenbau Gesellschaft Nürnberg" has always devoted itself to the construction of high power engines and won a well-earned reputation. The experience and practice acquired in this construction, as also the use of powerful and improved tools, placed this company in the best position for constructing large gas engines. This company quickly discovered that the use of the single-acting engine, whose dimensions were being increased and cylinders multiplied in order to obtain sufficiently powerful engines for modern requirements, was only transitive, the space occupied, the enormous weight and low efficiency of these types of engines being defects which caused them to be abandoned in favor of the double-acting type. Still, for small powers, up to 175 HP., the Nürnberg Co. makes the single-acting engine and even of double this power, if necessary, by using twin-cylinders side by side. This company, moreover, commenced to construct these in 1889.

Fig. 7 shows the way in which the piston and the exhaust valve are cooled in large single-acting engines of the Nürnberg type, whose present construction differs slightly, as regards the valve gear, from what is shown in this section. The circular slide valve which regulates the air and gas inlet is, in the new valve gear, fixed to the stem of the inlet valve, as in Fig. 26, which is a diagrammatic representation of this arrangement. In Fig. 7 it is seen that this slide valve was independent. Its motion was regulated by the governor, while in the present arrangement, the governor acts on the stroke of the inlet valve, increasing or reducing it as shown in Fig. 27. The variation of the travel of the inlet valve is effected by the displacement of the fulcrum of the operating lever L. This fulcrum is formed by a roller r, attached to the governor by means of a rod T. In order to prevent the accumulation of surplus oil and dirt, the seat of the exhaust valve has been slightly depressed, under the bottom level of the cylinder. An original device consists also in the mode of attaching the connecting rod to the piston. It is, of course, well known that the piston pin is placed at the two ends in bosses cast with the piston sides, where they are then kept by screws; the bearing at the end of the connecting rod is fitted between these bosses.

The Nürnberg construction is different. It consists according to Fig. 28 in holding the two ends of the pin in a fork at the end of the connecting rod bottom end, and in causing it to turn, at the center, in a bearing carried by a support cast in the vertical axis of the piston. In short, although the single-acting engine of the Nürnberg Co. has formed the object of several substantial improvements, it is the construction of double-acting engines that this company especially excels.

Fig. 29 shows the mechanism for the admission of the double-acting engines of the Nürnberger Maschinenbau. T is the eccentric rod receiving its movement from the side shaft and the end of which is maintained by the connecting rod B at the same time it is connected to the ratchet piece D. The latter engages the end of the lever L, which is connected also to the valve stem. The lever L rests on the lever l as a point forming a rolling path, and which is also jointed at the valve stem while its free end can move downward owing to the displacement of the pivot p controlled by the governor by means of the cranked lever l. A is an air piston which deadens the fall of the valve on its seat when the levers D and L disengage. It will be seen that according to the position which the governor causes the pivot P to assume the fulcrum advances or recedes, and the valve opens more or less late relatively to the stroke of the piston. The opening of the air inlet valve being constant and that of the gas being variable from the point of view of the time when it takes place, air only is first admitted which follows the piston, and more or less gas is afterwards admitted in proportion to the work to be developed. The device therefore effects the admission of a mixture of variable composition but with constant compression. These engines are made, according to the power required, with one, two or four cylinders. The single-cylinder engine is made up to 1,500 HP., the two-cylinder up to 2,800 HP. and the four-cylinder up to 5,900 HP., forming in the latter case two tandem engines arranged side by side and driving the same crank shaft.

Diagram Fig. 30 shows the succession of the strokes of the twin-tandem arrangement in two revolutions of the flywheel.

Guided by experience, the Nürnberg Co. advises the valves and cylinders to be dismantled and examined monthly, because, despite the perfection which the processes of washing and purifying producer or blast furnace gas have attained, accumulations of impurities are still to be feared. This company has therefore endeavored to arrange the parts, so that they lend themselves to the easy dismantling of the heaviest pieces and, from this point of view, the conetruction is a remarkable one. Fig. 31 shows, in a tandem engine, how the back covers are removed to afford access to the corresponding valves. The same operation is effected with the front covers of the cylinders, but by placing the crank at the end of the forward stroke. Fig. 32 shows the way in which the pistons are removed, i. e., by disconnecting the connecting rod from the piston rod and taking out the latter with the front cover, while the rods themselves are disconnected at the center in order to liberate the back piston.

The longitudinal section of the single-cylinder engine is shown in Fig. 33. We see there the details of the inlet valve and the gas regulating valve, balanced with double seat, also exhaust valve boxes formed by a vast chamber with water circulation, while the cross section, Fig. 34, through the gas and air inlet piping shows the mode of attachment of the cylinder to the frame, the operation of the valves by eccentrics and rolling paths, also the water circulation round the cylinder which is cast in one with its jacket. The cooling of the piston is effected by a water circulation introduced through the rod by the back crosshead, by means of articulated piping which follows its to-and-fro motion, Fig. 35. This circulation, after having traversed the piston, Fig. 36, passes through the rod and the front crosshead. The stuffing-box of the piston rods is shown in a longitudinal section in Fig. 37.

In order to give an idea of the huge dimensions attained by the large engines made by the Nürnberg Co., a few of the separate parts are described: Crank shaft, diameter 600 mm. × 9.570 m. (23.6 ins. × 31 ft. 4¾ ins.) length, weighing 20,000 Kgs. (19.68 tons), for 3,000 HP. twin-tandem engine, diameter of pistons D=950 mm. (37.4 ins.) and stroke 1,200 m. (47.2 ins.) Frame, one solid casting, weighing 27,000 Kgs. (26½ tons). These parts are intended for the Rombach Steel Works, Lorraine, where they are to complete an installation of 12,500 HP. for the electric service and blowers.

Among the largest engines may be mentioned those of 3,000 HP. twin-tandem, forming part of a group of 9,100 HP. of the "Schalker-Gruben and Hüttenverein" of Gelsenkirchen. Mention may also be made of the installation of 12,000 HP. in six units executed for the electric station of the "Sociedad de Gasificacion Industrial of Madrid," which is driven, as also a 350 HP. engine, by fuel gas generated by Duff producers. From 1903 up to the end of November, 1904, the Nürnberg Co. had supplied and had in hand 106 engines of its double-acting type, representing a total power of 114,070 HP. These engines are driven by blast-furnace gas, coke-oven gas and producer-gas and are employed as follows: For the electrical service, continuous or alternating current, 79 engines, equivalent to 78,220 HP.; for blowing apparatus, for blast furnaces, steel works, rolling mills and various applications; 27 engines representing 35,850 HP.

EHRHARDT AND SEHMER ENGINE.—The firm of Ehrhardt & Sehmer, of Saarbrucken, in Alsace, has also won distinction for the construction of large engines and has built, in the short space of three years, some 15 engines representing a total of 12,680 HP., on their double-acting system, in which they also arrange the cylinders, as the case may be, either twin or tandem. Fig. 38 shows in a longitudinal and cross section through the inlet valve a cylinder of the 700 HP. tandem engine. The valve gear is arranged in order to obtain a mixture of constant composition, admitted in a variable quantity under the action of the governor. For this purpose there is one mixture inlet valve of variable lift and a lantern-shaped valve, the variable stroke of which determines the quantity of mixture admitted. The cylinder is cast in one piece with its jacket, but the latter, owing to the large amount

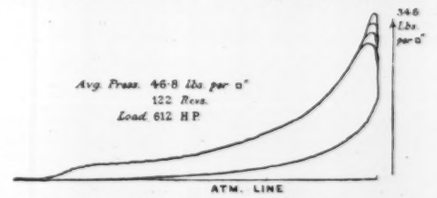


Fig. 44. Indicator Diagram from 1,000-HP. Engine. (Oechelhaeuser.)

of space, can expand freely, having regard to the elasticity of the casting at the places where these two parts join. The makers have also endeavored to obtain symmetrical forms, in order to secure equality of tension in all the parts. It will be noticed that large manholes are provided everywhere, to give easy access to the jacket. At each end of the cylinder there are two independent contact breakers for the electro magnetic ignition. We also find in the Ehrhardt and Sehmer engine arrangements for the cooling, controlling, etc., which are common good types of gas engines.

DINGLER ENGINE.—The Dingler engine, Fig. 39, made by the Dingler Engineering Works of Zweibrücken (Alsace), differs materially, from the point of view of the system, from the devices employed by other makers of large engines. Instead of obtaining the double action in a closed cylinder by exploding the mixture alternately on each face of the piston, in the Dingler engine two cylinders open at one end are united at their explosion chambers. As is shown in Fig. 40, each of these cylinders contain a piston, the two pistons being connected together by an internal rod. The explosion is therefore produced alternately on each inside face of these pistons. The rod common to the piston is provided with rings and works in a casing, passing through to the division common to the two parts of the cylinder. This division, as also the jacket of the double cylinder, is provided with a water circulation. The valves are arranged in the division piece, as in the single acting engines. The sys-

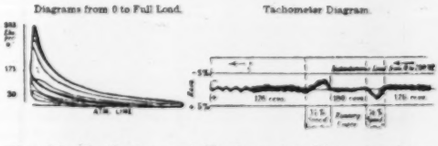


Fig. 45. Indicator and Tachometer Diagrams from 200-HP. Double-Acting Engine, 180 Revs. (Otto-Deutz.)

tem avoids the use of piston rod stuffing boxes. It lends itself to the free expansion of the jacket and inside cylinders, which are only solid at the one end. As the cylinders are open their supervision and upkeep are as easy as in the case of an ordinary single-acting engine. The governor acts on the admission, Fig. 42. The valve, with a constant stroke, always opens at the same place, but closes later or sooner so as to effect the admission of variable charges with constant composition of mixture.

The device, Fig. 43, which effects this movement is somewhat complicated. Besides the ordinary side shaft,

which carries the cams b, there is a secondary shaft a receiving its movement from the first shaft but turning twice as quickly, i. e., at the speed of the crank shaft. The axial governor is fitted on this secondary shaft, also a tube o to which the governor imparts a slight rotary movement. This tube carries a cam d, which is consequently movable. Another cam k is fixed on the ordinary shaft b. The simultaneous contact of the two cams, through the medium of a set of cranked levers controls the opening of the valve and the latter closes the earlier or later according to the position of the movable cam, under the action of the governor.

CONCLUSION.—The principal makes of large gas engines constructed on the Continent have now been described and reference has been made to the methods and principles which guide the makers. It would, therefore, be of interest to analyze concisely a few of the details and the indicator diagrams taken. Of the two-cycle

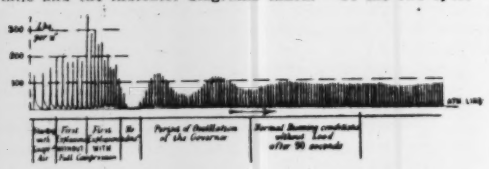


Fig. 46. Mathot Explosion Record from a 200-HP. Double-Acting Engine. (Otto-Deutz.)

engines the diagram, Fig. 44, taken on an Oechelhäuser engine of 1,000 HP., is reproduced. The engine was working with blast furnace gas. The mean pressure corresponding to the work of 612 HP. shown by the diagram is only 3, 3 Kg. (47 lbs.). It will be seen that the exhaust, the air flush (scavenging) and the admission of the charge are effected in about ⅛ of the total stroke of the two pistons.

The superposed diagrams and the tachogram, Fig. 45, are taken from an Otto-cycle double-acting engine of Otto-Deutz make, driven by a suction gas-producer. The indicator diagram shows the variations of the compression and corresponding explosive pressures. The tachometer diagram shows that the sudden alterations of load between working light and the maximum work produced, over or under, variations of speed of 3½%.

Table 1 gives the interesting details of a test made with this engine. It is remarkable for the low consumption of 0.705 lbs. per brake HP. obtained, especially when it is considered that the test took place under regular working conditions, i. e., taking into account the fuel consumed at night for keeping the producer hot during the stoppage of the engine. Fig. 46 is the reproduction of explosion record taken at the time of starting; it shows the phases of this operation. It will be seen from the diagrams, Fig. 47, taken at the front and at the back of one of the two cylinders of a Nürnberg engine of 1,000 HP., that mean pressures of 6 to 6½ kg. (85 to 93 lbs.) are obtained, even with blast-furnace gas, the mean heat value of which is only about 110 B. T. U. Such mean pressures are not, however, usual, and is customary among the large firms on the Continent to calculate the working dimensions of engines (diameter, stroke of piston and number of revolutions) for mean pressures not greater than 70 lbs. per sq. in. They thus leave a wide margin to cover fluctuations in the quality of the gas or temporary defects of regulation caused by lack of care or negligence on the part of the attendant.

The mean piston speed has also been increased, and has now reached without difficulty 800 to 850 ft. per minute, while it was a few years ago 650 to 750 ft.

It is advisable, before closing this paper on the new motive power which utilizes every kind of fuel gas produced commercially, to point out the principal difficulties which remain to be overcome in order to enable large engines working with poor gas in general to work with safety, facility of control and upkeep; such attributes appear to have remained the special feature of the steam engine. Economically the gas engine is evidently superior, but low consumption is not the only quality which users require from a motive power. It is necessary above all that it should be free from the risk of sudden stoppages which lead to great expense, as they hamper production and may be at times fatal in certain industries where breakdowns must be specially avoided; such is the case with electric stations, pumping, hoisting and ventilating work in mines, etc. The principal causes of breakdowne in engines fed by gas other than town gas, which undergoes a complete purification, consists in the fouling of parts, such as the pipes, the valves and the cylinder, by impurities in the gas.

In large installations where it is extremely important to avoid breakdowns, recourse is had to special means of washing and purifying, by the use of centrifugals and other apparatus. But although these succeed in reducing to 1-5 gramme per cubic meter the amount of dust accompanying the gas, they still allow the passage of tar, which is the principal element destructive to the engine. This tar adheres to the sides of the passages, causes the valves and piston-rings to stick, thus preventing their proper action. It also deposits itself in the cylinder, where it finally gives rise to premature ignitions. Certain coke-oven gases contain as much as 1 gramme of tar per cubic meter. It is this very question of tar which compels us, in order to avoid great complications, to employ exclusively non-caking anthracite coal for suction gas-producers now so largely in use owing to their simplicity and economical efficiency. As tar is a product of distillation of the volatile carbons (carbides) which escape on combustion and on the conversion into fuel gas, it is to our interests to reduce them in the producer itself. Different systems have been proposed, among which is the system of inverted combustion, which is said to have the result of burning the volatile matters as they are given off and the distillation of the hydro-carbons in the independent reducers. It must be admitted that so far the efforts of the inventors have not met with the success expected. The caking of the fuel and the formation of cavities injurious to the regularity of combustion constitute the principal difficulty to combat. The use of bituminous coal, especially in suction gas-producers, is not therefore a question which has been industrially accomplished.

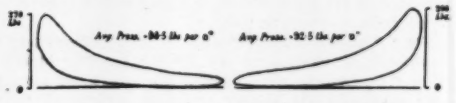


Fig. 47. Diagram from 1,000-HP. Gas Engine, 100 Revs. (Nuernberg.)

Whether it is producer gas, blast-furnace gas, or coke-oven gas which is used, their purity is an important factor in the proper working of the engines which they feed. The organic defects of large engines do not appear to play in this respect a preponderating part. They should, however, be perfected as regards facility of access and upkeep of the parts, such as valves and piston. The oil consumption should be low, and they should be made less susceptible to variations in the quality of the gas. The skill of our experts and our makers will, we have no doubt, soon overcome these latter difficulties. Large gas engines will then constitute one of the most remarkable industrial victories of the age in which we live.

TABLE 1.—Test made on a gas plant of a 4-cycle double-acting engine of 200 HP. and a suction producer in the works of the Gasmotoren Fabrik, Deutz-Cologne, the 14th and 15th of March, 1904, by Messrs. A. Witz, R. Mathot and de Herbais de Thun.

(Piston diameter: 21¼ ins. × stroke 27 9-16 ins. Diameter of piston rods: Front, 4¼ ins.; rear, 4 5-16 ins.)

	Engine.	Mar. 14.	Mar. 15.
1	Average number of revolutions per minute	151.29	150.20
2	Corresponding effective load; BHP.	214.22	222.83
3	Duration of the tests; hours	3	10
4	Average temperature of water after cooling the piston; deg. F.	117.5	
5	Average temperature of water after cooling the cylinder and valve-seats; deg. F.	135	
6	Water consumption for cooling the piston per hour; gallons	39	
	Producer.		
7	Nature and origin of fuel: anthracite coal, "Bonne Esperance et Batterie," Herstal-Belgium		
8	Heating value of fuel: B.Th.U.	14,650	
9	Consumption of fuel per hour plus 53 lbs. during the night of the 14th inst. for keeping the generator fired during 14 hours, the engine being stopped; lbs.	199	160
10	Water consumption per hour in the vaporizer; gallons		14.2
11	Water consumption per hour in the scrubbers; gallons		318
12	Average temperature of gas at the outlet of the generator; deg. F.		558
13	Average temperature of gas at the outlet of the scrubbers; deg. F.		62.5
	Efficiencies.		
14	Gross consumption of coal per BHP. and per hour; lbs.	0.927	0.720
15	Consumption of coal per BHP. after deducting the moisture	0.907	0.704
16	Thermal efficiency relating to the effective HP. and to the dry coal consumed in the generator; per cent.	19	24.4
17	Water consumption per brake horse-hour:		
	For the cylinder, stuffing boxes, valve-seats and jackets; gals.	4.65	
	For the piston and piston rods; gals.	1.73	
	For the vaporizer; gals.	0.0655	
	For washing the gas in the scrubbers; gals.	1.42	
18	Water converted in steam per lb. of fuel consumed in the generator; gals.	0.193	

TAX RATES, TAX VALUATIONS AND INDEBTEDness of Massachusetts cities for the year 1904 are given in an appendix to the monthly bulletin of the Boston Statistics Department for January-March, 1905. The tax rates of the 33 cities of the State ranged from $21.60 per $1,000 valuation for Taunton to $14.60 for Springfield; and the net debt (gross, less sinking fund) from $121.66 per capita for Newton to $16.77 for Salem. The total valuation of Boston was $1,237,068,851, of which only $231,915,951 was personal property. The gross indebtedness of the 33 cities was $170,031,448 and the net indebtedness was $118,880,259.

MOSQUITO EXTERMINATION AS A PROTECTION AGAINST YELLOW FEVER AT HELENA, ARK.

By P. H. Wright.*

All city work here has been suspended on account of the rigid quarantine against yellow fever and the utilization of the combined forces of the engineering and street departments in preliminary sanitary measures. The whole city and environs (about three square miles) are patrolled by an oiling force after each rain and all ditches and ponds on public property are oiled. Although we have an excellent artesian water system which has been in operation about twelve years; there are still about 500 old cisterns that contain water. There are also some of wet cellars in the business district. These cisterns and the water in the cellars were all oiled by the city force about three weeks ago but are now oiled by the owner under an ordinance recently passed (reprinted below—Ed.).

We have about 1½ miles of canal of 10 to 20 ft. water width and about two miles of small ditch and numerous wet spots and about three or four acres of ponds. All of the edges of the flowing ditches are oiled. Every wet spot and ditch in the whole territory was covered yesterday with oil at a cost of about $61. There were three parties, each party consisting of one foreman at $2, two sprinklers at $1.25 each and one driver. Two single-horse wagons and a driver cost $2 each and one two-horse wagon and driver cost $2.50; or the total force cost $20 a day. The foremen kept notes of all places oiled and the drivers pumped the oil into the sprinklers as they were returned to the wagons. There were about 7½ tanks (of 53 gallons) used at a cost of $5.57 each, or a total of about $41; making about $61 for oil and labor. The oil was of course used liberally.

Our sewer system has been in operation only about two years and we now have about 700 connections of tested modern plumbing. The police court is very busy every morning with those who have not made sewer connections.

The main part of the ordinance providing for draining or oiling stagnant pools of water, which was approved on Aug. 12 by Mr. Hugh Martin, Mayor of Helena, is as follows:

AN ORDINANCE TO IMPROVE THE SANITARY CONDITION OF THE CITY OF HELENA BY PROVIDING FOR THE REMOVAL AND OILING OF STAGNANT POOLS OF WATER.

Be it ordained by the City Council of the City of Helena, Ark.:

(1) That the owner or occupant of any and all lots or parcels of land within the corporate limits of the city of Helena, Ark., be, and they are severally hereby, ordered and required to abate and remove any stagnant pools of water existing upon their several premises in all places where water stands for 24 consecutive hours after raining has ceased, by draining the same where proper drainage can be secured by connection with the city's main ditch, otherwise by filling up the same with dry, clean earth. And said several owners and occupants are also hereby required to remove all vessels, cans, barrels, tubs or other places in which standing water may remain upon their said premises. And it is hereby further required of said owners and occupants that all cisterns and other places containing water which cannot reasonably be immediately filled up or drained be at once covered with a coating of kerosene oil, not less than 4 ozs. to every 10 sq. ft. of water surface, which oil shall be renewed once every two weeks and after each rain from May first to November first in each year. Provided, cisterns and water barrels in actual use may be properly screened in lieu of oiling.

Sec. 2 declares violation of any part of the ordinance a misdemeanor, punishable by a fine of not less than $10 nor more than $100. Sec. 3 is the usual repealer and provides in addition that the ordinance shall take effect immediately.

THE SURFACE CONTACT SYSTEM of electric traction is undergoing trial in Dresden, Germany, on a short section of the city's street railway. The Kingsland form is used; in this form the contact studs, placed about 10 ft. apart, are energized by a switch which is thrown mechanically by the passing car. The switch is placed just outside of one track-rail, below the surface, under a slot formed between the track rail and an adjoined slot rail, where it is actuated by a dog projecting down from the car. In this system the contact studs, which deliver power to the car through a longitudinal metal skate held on the lower side of the car, are as usual placed in the middle of the track, nearly flush with the pavement surface. They have an iron cap set in a block of cement, and contain no moving parts.

*City Engineer, Helena, Ark.

THE GIBB'S HILL LIGHTHOUSE, BERMUDA.

By Robert A. Cummings,* M. Am. Soc. C. E., and C. W. Reinhardt.†

The Bermuda Islands, rising from a submarine plateau of coral formation, are approached by vessels along an unusually dangerous and tortuous channel which follows the northeast coast line of the main islands, then turns south and finally due east to the inner harbor of Hamilton. The St. David's Island Lighthouse, exhibiting a fixed white light of the second order from the extreme northeast end of this group of islands, guides the mariners approaching the Bermuda group from the north. The Gibb's Hill lighthouse, which is described below, is located on one of the highest hills of the main island, south of the outer harbor in Lat. 32° 14′ 45.3″ N. and Long. 64° 49′ 55″ W. The focal plane of the light is about 362 ft. above high water, and its range is 27 miles. The light is of the first order dioptric,* revolving, giving a flash of 8-10 seconds duration once in every 10 seconds from sunset to sunrise. The tower was constructed of cast iron by Messrs. Cottom & Hallen, of London, from designs of Mr. Alexander Gordon, C. E. The first plate of the tower was placed Dec. 12, 1844, and the last plate on Oct. 9, 1845. The original light was shown May 1, 1846, and consisted of annular central lenses with reflecting catoptric zones. The tower is 133 ft. high, of 24 ft. outside diam. at the base, and tapering to 14 ft. at a point 3 ft. below the balcony floor, then springing out to 20 ft. to form the balcony. The lantern room is a polygon of 16 sides, 16 ft. diameter at base outside measurement. The tower is formed of 135 concentric cast-iron plates ¾-in. in thickness, with flanges of 3 ins. around their perimeters and fastened together by means of screw-bolts through these flanges.

There are seven floors of similar plates bolted

*House Building, Pittsburg, Pa.
†220 Broadway, New York City.
*See "Notes on the History of Lighthouses," elsewhere in this issue.

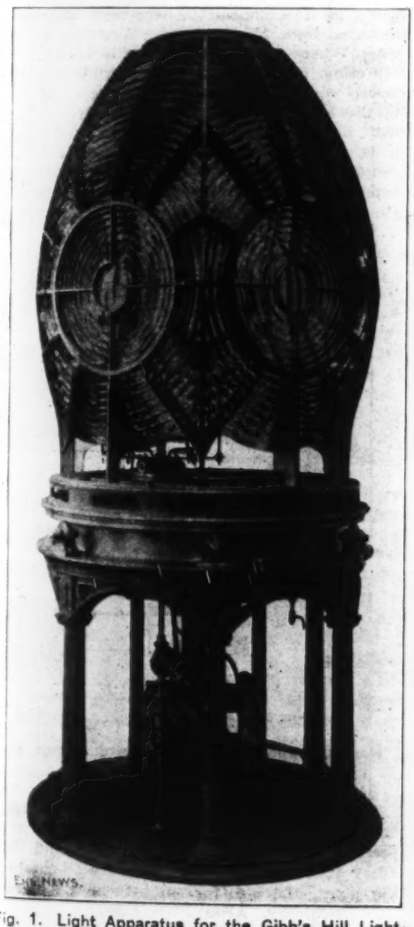


Fig. 1. Light Apparatus for the Gibb's Hill Lighthouse, Bermuda.

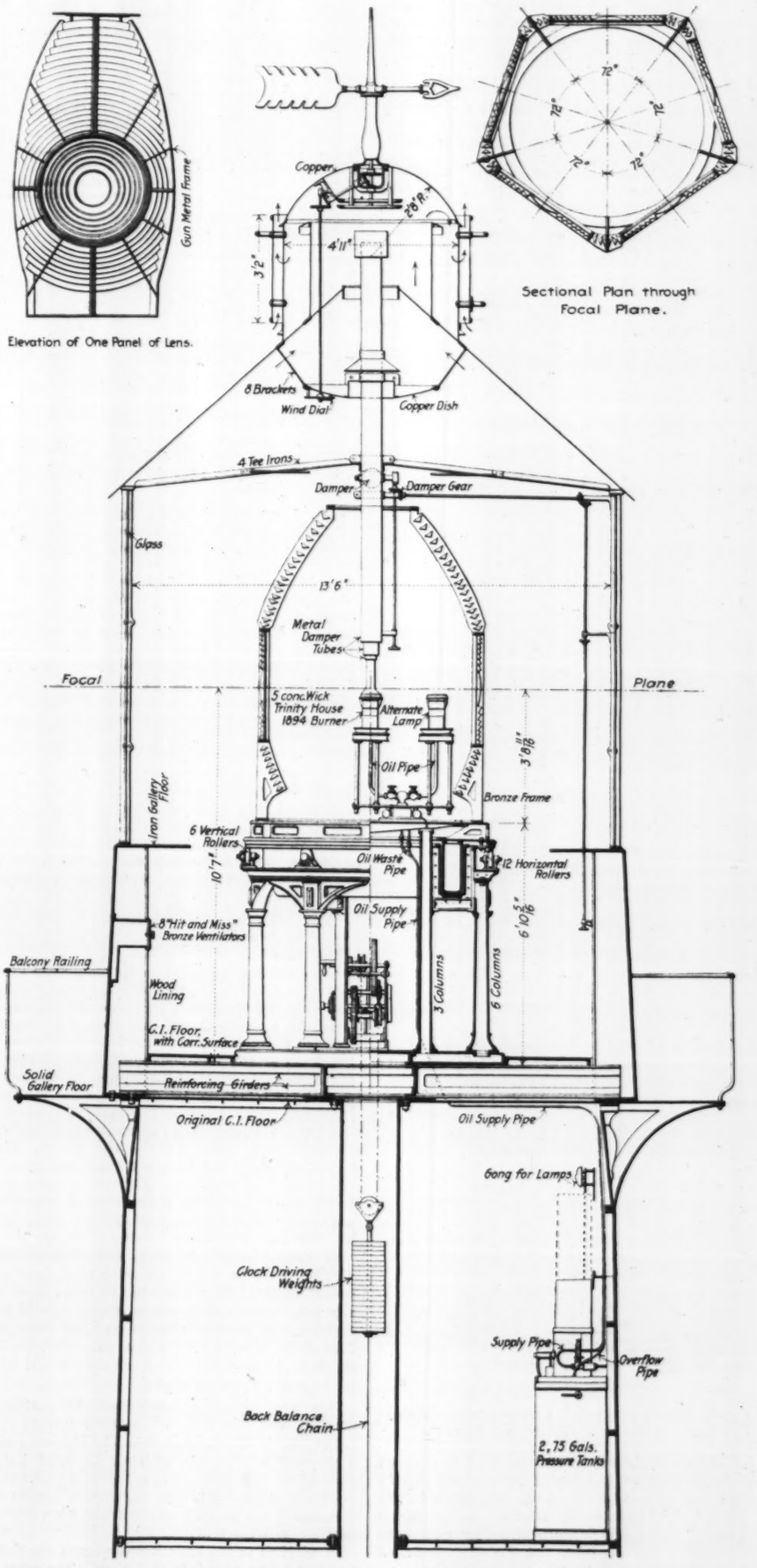


FIG. 2. LANTERN-ROOM OF THE GIBB'S HILL LIGHTHOUSE, SHOWING LIGHT APPARATUS.

to the sides and to a central hollow cast-iron column of ¾-in. metal and 18 ins. inside diameter. The head room for each floor is 12 feet. The communication between floors is by means of a spiral iron staircase. The first and second floors are cased in brick and concrete work, to give stability during hurricanes which sometimes occur during September. A wind velocity of 125 miles per hour was recorded here in September, 1899.

The whole structure was thoroughly overhauled in 1898-9. When in the spring of 1903 the steamer "Madiana" foundered on the reefs north

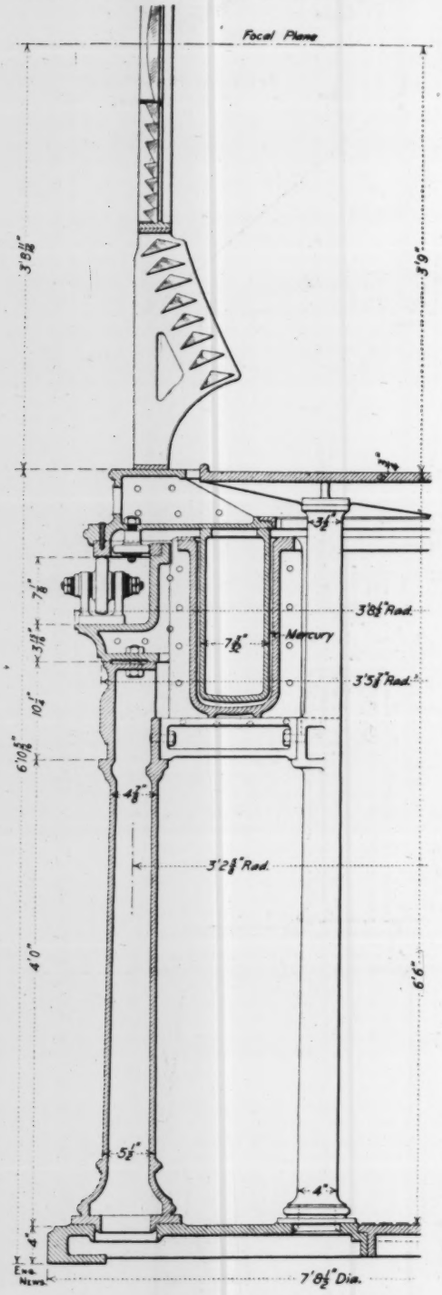


Fig. 3. Details of Lantern Pedestal, with Mercury-Bath, Gibb's Hill Lighthouse, Bermuda.

of the main island, the owners of the vessel claimed that the insufficient light of the Gibb's Hill lighthouse was to blame. Therefore it was decided by the colonial government to install modern lenses and apparatus. The new light was put in place in 1904, and was first shown on September 26, of that year.

This light apparatus was made by Messrs. Chance Bros. & Co., Ltd., Birmingham, England, after designs by T. Matthews, M. Inst. C. E., Chief Engineer, Trinity House, and consists of optical panels, pedestal, clockwork, pressure lamps and burners. It is a first order revolving dioptric light of nearly 1,000,000 candle power, with catadioptric zones, the glass prisms of each face being concentric with the polyzonal lenses. The light apparatus floats and revolves in a mercury bath, as shown on the drawings. Oil of 300° flash test is used, and is supplied under constant pressure from accumulator reservoirs located in the floor below the light room.

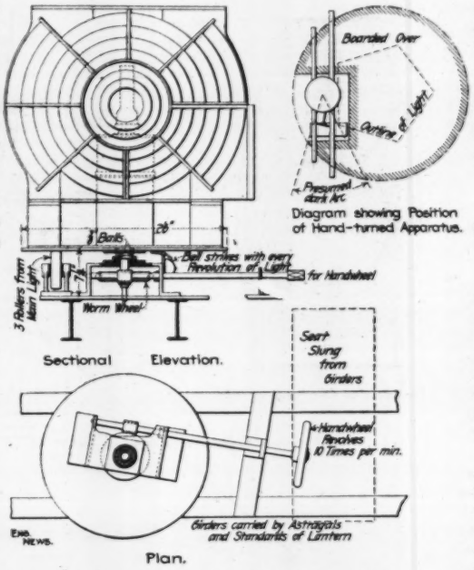


Fig. 4. Temporary Revolving Light Apparatus Used During Erection of Permanent Light Installment, Gibb's Hill Lighthouse, Bermuda.

There are two lamps provided so as to be used alternately or in case of accident to one. These swing on a common center and are shown in the drawings. This apparatus was so much heavier than the one it replaced, it was necessary to provide reinforcing steel girders, as shown, which rest on the outer shell of the tower and carry the entire apparatus.

The apparatus was purchased complete by the colony, and installed under the immediate direction of Mr. Wm. Cardy Hallett, C. E., Colonial Surveyor, by his forces acting under an expert from the manufacturers, in about five months. The parts were boxed, shipped and delivered to the base of the lighthouse. A vertical row of panes was taken out of the lantern room, and all material hauled up by means of a gin pole erected on the balcony and assembled in place in the lantern room. The heaviest piece was the mercury bath, constructed after Mr. T. Matthews' designs, which weighed about two tons.

Each face of the lense is divided into five parts or bronze frames; these were taken up separately and bolted together in position with great care. No hurricanes occurred during erection, which was successfully completed under considerable difficulties owing to the necessity of maintaining a light at this place during the installation of the new one. In regard to this matter it was at first decided to do without a revolving light altogether during the term of erection, but the Admiralty insisted that a light of that description would have to be maintained at night.

This was finally accomplished by using a smaller light, shown on the drawing, located on a temporary wooden platform in the lantern room, and continually revolving same by hand power throughout the night during the entire period of erection. This temporary light was located on one side of the permanent work and answered its purpose satisfactorily.

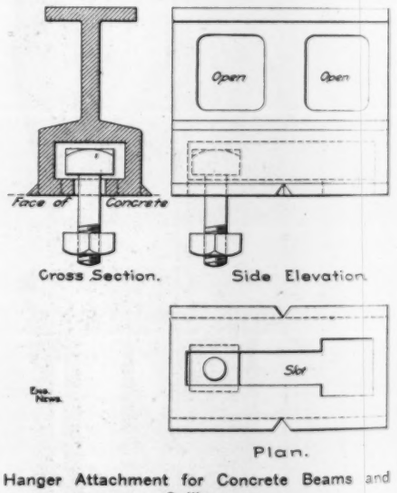
In addition to the light, a new copper ventilator and vane was added at that time. The color of the lighthouse is white and a new coat of paint is given annually. The cost of these improvements was about $20,000. The annual expenses of salaries, maintenance, etc., are about $2,200.

We are indebted to Mr. Wm. Cardy Hallett, C. E., Colonial Surveyor, Hamilton, Bermuda, for facilities extended in preparing this description, as well as for drawings and photographs from which the illustrations accompanying this article have been prepared.

HANGER ATTACHMENT FOR CONCRETE BEAMS AND CEILINGS.

In concrete buildings, and especially in those for manufacturing purposes, some form of attachment is required for the hangers for shafting, heater and sprinkler pipes, etc., and in our issue of March 3, 1904, we illustrated several forms of attachments of this kind. The application of one of these to the new factory buildings of the United States Shoe Machinery Co. was described in our issue of May 5, 1905.

A large concrete building has recently been erected at St. Paul, Minn., for the wholesale hardware firm of Farwell, Ozmun, Kirk & Co., and here a special form of attachment is used which was designed by this firm and is now handled as one of its specialties. This is termed the Acme adjustable concrete insert, and consists of a malleable iron casting embedded in the beam and having a T-slot in the bottom to receive the head or nut of the bolt holding the hanger. Where a rigid connection is required the nut is inserted, but for some purposes the head of the machine bolt is inserted in the slot. The bolt can be readily put in or removed, and is adjustable for a distance of 1¼ to 2 ins., according to the size of the casting. The castings weigh from 4 to 18 ozs. each, and the general shape is shown in the accompanying cut. They are easy to attach, as the adjustable feature avoids the necessity of placing them in exact alinement. They stay where they are placed, which is a very important point, as it is difficult to keep men with wheelbarrows from knocking over anything in their way. Where possible the insert is bolted to the centering, and this is always possible where the inserts come in the floor slab. Where they come in the beams, a light galvanized strap is used, with holes punched in the ends to take two 12d nails. This fastens them on very securely. The centering pulls off the nails, and the points which extend down below the surface of the beam are clipped with a cutting nipper.



Hanger Attachment for Concrete Beams and Ceilings.

The inserts are being used in this building for the attachment of the entire sprinkling system, for all the wiring boards (which extend down every aisle through every floor), for all the heating pipes, and also for the attachment of some light machinery. About 4,000 of these attachments have already been placed and in all about 12,000 will be required for this one building.

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That not all Arkansas engineers take the same attitude towards mosquitos and yellow fever as did one of our correspondents in our issue of Aug. 24 is shown by the interesting and practical article on mosquito extermination measures at Helena, Ark., published elsewhere in this issue. We commend the article to our readers both for the information on mosquito fighting which it contains and for an example of the value of short, right-to-the-point descriptions and cost statements of novel pieces of work carried out by engineers. We are in little or no danger of yellow fever in the Northern United States, but malaria prevails over large, populous and wealthy sections and might be greatly reduced by such mosquito engineering as Mr. Wright describes and as has been done in a few northern localities. Even if there were neither malaria to give one chills and fever or yellow fever to kill one, yet mosquito extermination would repay many communities a hundred fold on the small investments needed to that end.

The city of Pawtucket, R. I., deserves great credit for having fought to what looks like a finish the alleged septic tank infringement suit brought against it by the American Sewage Disposal Co. Other municipalities have weakly compromised rather than go to the trouble and expense of determining their legal rights in similar cases. Thus, the village of Liberty, N. Y., settled with the company just named and the city of Plainfield, N. J., settled with the Cameron Septic Tank Co. of Chicago. Fortunately, Saratoga Springs, N. Y., and several municipalities near Chicago have combined to defend infringement suits brought in the interests of the Cameron patents, so municipalities and engineers alike may soon expect to know where they stand as regards paying royalties for using the septic tank. It may be as much as three years, however, before the Cameron case is finally settled, as it has not yet been passed on by a lower court, even. It is possible, also, that the Glover patent may be taken to the U. S. Supreme Court, and if so that the sweeping decisions of the lower U. S. Courts might be reversed. Henceforth, however, the chief interest will more than ever center in the Cameron septic tank patents. It should be added that the validity of the Glover patent was not an issue in the Pawtucket case. The foregoing comments should not be construed in any other sense than as an expression of opinion regarding the desirability of having it determined once for all whether the Glover patent has any possible relation to the septic tank, and whether or not any patent on the septic tank process is valid. So long as these questions are open to debate the solidarity of interest which should exist among municipalities ought to lead any one of them to unite with others in settling the questions at issue instead of compromising to avoid trouble to itself and thus increasing the trouble caused other municipalities.

The American citizen is more tolerant of public nuisances than any other civilized being. This may be on account of the fact that he believes the Constitution guarantees every one the right to create a nuisance regardless of his neighbors, so long as he does not kill or rob or commit a similarly grievous crime. Whatever the cause, the fact remains. We endure the tin horn, the factory whistle, the push-cart, the builders' dirt-pile and the advertising sign, or at least we feel that there is no way of stopping them. Similar sentiments have left us so long inactive—or at least unsuccessful in our sporadic activity—concerning the smoke nuisance.

Everybody, it is safe to say, concedes the smoky chimney to be a nuisance. But the view is a passive one. Formerly, and to some extent even to-day, the argument was: "We can't stop our chimney from smoking." Technical advance and commercial development have made combustion a more manageable procedure, and to-day the old argument is replaced by "What are you going to do about it? You can't expect me to spend a lot of money putting in fancy devices to prevent smoke!" This latter argument can be met only by fact: the fact that the law says he must prevent smoke. This work, a function of municipal governments, is in successful progress and will ultimately lead to a general recognition that smoke is not only not wanted but also that it need not be suffered.

A relatively few but yet a slowly growing number of American cities have entered on a fight against smoke, and a far larger number of individuals and civic organizations are now engaged in the struggle. The solution of the problems involved means much to engineers and to proprietors of industrial establishments. To all the just-named classes we commend Mr. R. P. King's interesting paper on municipal smoke prevention read Aug. 23 before the Toledo meeting of the League of American Municipalities and reprinted nearly in full elsewhere in this issue.

MATHEMATICS FOR ENGINEERING STUDENTS SHOULD BE TAUGHT BY ENGINEERS.

Has pure science any legitimate place in the courses of study prescribed by engineering colleges? Mathematics, botany, geology, and several other subjects are taught as pure sciences rather than as applied sciences in most of our engineering courses. At the recent convention of the Society for the Promotion of Engineering Education the advisability of continuing this practice was seriously questioned in the discussions of certain papers; and it is apparent, from the present trend of ideas, that the question heading this article is one that will be asked with greater earnestness from year to year. Time was, and that quite recently, when to suggest a possible improvement in methods of teaching mathematics to engineers would have met with scant consideration. But that time is rapidly passing away. Instructors are asking whether it would not be better to have mathematics taught by engineers, and taught as a tool to be used in solving engineering problems. It may be good mental training to deduce the equation of the lemniscate, but equally good training can be had by solving problems involving curves more frequently used in engineering.

As there are two kinds of physical training, so there are two kinds of mental training. A man may build up his muscles by exercise in a gymnasium or by chopping wood, but, if he expects to earn his living by wood chopping, he had better engage in chopping at once rather than in pushing dumb-bells. The pure science method of instruction may be called a system of mental gymnastics. It is good training, but not so good as the exercise of the brain on problems of applied science. Applied science may be made to yield fully as great mental power, and in addition it saves time by making an engineer of a young man earlier in life. Moreover, it leads to greater effort on the part of the learner, because it stimulates his interest in his work. He sees, from the first, the practical value of his study. He realizes at once that he is working with the tools of his future profession.

When an engineering student has to be told that he must study a subject because it will be of use to him in the future, something is wrong with the method of teaching that subject. There is hardly a step in mathematics that can not be illustrated by a practical engineering example. If there are many such steps that can not be so illustrated, they are pretty sure to be superfluous.

From the frequency with which erroneous solutions of engineering problems come to this office, we infer that many engineering graduates have had too much pure mathematics and too little applied mathematics. Errors of mathematical logic are far more common than errors in mathematical processes. Students have learned how to integrate without having learned how to "set up" a problem correctly. Now, it is apparent that under proper instruction in applied mathematics, so large a number of engineering problems should be given that the student would enter his course in higher mechanics with a good fundamental knowledge of mathematical logic, and upon finishing his mechanics (including hydraulics) he would be a master of mathematical logic, and not a mere memorizer.

In passing, we wish to call attention to what appears to us to be a fatal tendency in the present courses in stresses in framed structures, namely, the use of too much graphics at the expense of analytical solutions of problems. Graphical methods, it is true, are time savers in practice, but they are also brain blunters—they dull the keen edge of reason, because they make the process of solving a problem largely a process of pencil and memory. It is noteworthy that a student who has once thoroughly learned how to solve stress problems analytically, seldom forgets how to attack such problems even after the lapse of years. On the other hand, the student who has neglected the analytical method soon forgets his graphics, and is at loss without his text book to guide him. His memory has been developed at the expense of his power of reasoning.

Returning to our main theme: If it is conceded that mathematics should be taught to engineers as an applied science, then it follows, as our first corollary, that every part of the mathematics which is likely not to be applied in practice should be struck out of the course. In a word, nothing should be left in simply because it furnishes "mental training." We now see why it is that text books on mathematics for engineers should be written by engineers.

Our second corollary is that duplicate demonstrations of formulas should be avoided. Any one who will take the pains to compare calculus demonstrations with those in analytical geometry will find an unexpectedly large amount of this duplication. As a rule, too, he will find that the calculus could have been substituted for analytical geometry to advantage. One of the speakers at the convention above referred to, urged the desirability of teaching calculus and analytical geometry at the same time and from the same book. This, we believe, is a step in the right direction, for it would lead to a clearer comprehension of the principles of higher mathematics, and would give more time for the "soaking in" process, so that calculus and analytical geometry would both be used with greater facility in solving problems.

It is now conceded that mathematics is best learned by solving problems. The problems should be largely of a practical nature and of a kind that the engineer is likely to meet later in life. Problems in mechanics may be introduced in the regular mathematical courses, and, in fact, the student would thus find himself possessed of a good grasp of the fundamental principles of mechanics before taking up the courses devoted to that subject by name.

Four years is a short time in which to learn where to find engineering data and how to apply them; but in many four-year courses the real engineering problems are not attacked until af-

ter the first year, and often not until after the second year. Many of the problems, however, could be introduced into the mathematical work of the first year—if mathematical books were written by engineers. Even were a repetition of the same kinds of problems to occur in subsequent courses, there would be no waste of energy; for, as above stated, it is actually desirable to let principles "soak in" for as long a period as possible, and repetition helps this "soaking in."

RAILWAY IMPROVEMENTS AND BETTERMENTS.

The improvement of existing railways is an extensive and important class of work which is in constant progress, but one which is apt to be overlooked as a class by itself, being often confused with the general work of maintenance. The engineering work of existing railways may properly be divided into three classes: (1) The construction of new lines and extensions; (2) the maintenance of way and structures; (3) the construction of improvements or betterments. The first of these is easily enough classified, as it may be regarded entirely independently of existing lines. A possible exception to this is where a long cut-off is built, and in such a case the question has been asked whether the expenses should be classed as "construction" or "improvement." It would seem, however, that where the cut-off supersedes the old route, it is simply and obviously a betterment; but if (as rarely occurs) the old route is also kept in operation, the cut-off might perhaps be regarded as a new line rather than as a betterment. The maintenance of way and of structures relate specially to repairs and renewals of existing lines and works, and the records and classification of the expenses for this class of work were discussed at some length in our issue of July 27, 1905.

The improvements or betterments which form the third class above referred to include work which is designed to increase the capacity for traffic, to facilitate the handling of heavy traffic, and to improve the general physical and operating conditions, frequently with a special view to enabling the cost of transportation to be reduced. These betterments include such work as grade and line revision, additional main tracks and sidings, rebuilding bridges to carry heavier engines and train loads, filling trestles, widening cuts and banks, signaling and interlocking plants, track elevation and depression, yard and terminal improvements, and shop extensions. It is probable that the enormous amount of work and expense represented annually by these betterments is not generally recognized. In the accompanying table we have classified some of the principal items of betterment expenses in 1904 for 17 railways aggregating nearly 62,000 miles. These expenses, of course, are distinct from the "maintenance" or "repair" expenses, but the distinction is not very clearly drawn under the present systems of accounting. The classified figures in the table are only approximate, owing to the entire lack of uniformity in classifying these expenditures in the annual reports from which the figures are taken. The total for these 17 roads, however, is nearly $50,000,000, and this indicates the amounts expended for work and material in the general improvement of the railway system.

Among the items not classified in this table the following are of interest: Signals and interlocking (six roads, $198,000; river protection works (two roads, $97,957; land for sheep pasture (C., B. & Q. Ry.), $71,603; coaling stations and automatic ore unloader (B., R. & P. Ry.), $59,950; timber treating plant (D. & R. G. Ry.), $41,181. In regard to yards and terminals, the New York Central Ry. spent nearly $1,500,000 on its improvements at New York and Weehawken during the year. The track elevation and depression on four railways aggregated $1,946,775, as follows: Chicago, Milwaukee & St. Paul Ry., $1,135,800; Chicago & Northwestern Ry., $567,730; Illinois Central Ry., $220,437; Chicago, Burlington & Quincy Ry., $23,602. All of this work was at Chicago, with the exception of $362,476 for the track depression of the Chicago & Northwestern Ry. at Milwaukee.

Many of the improvements have a direct relation to the operating conditions and expenses, and it may be of interest to note some of the improvements effected in individual cases. On the Northern Pacific Ry., in 1904, the revision of grade and alinement between Hope and Kootenai, on the Idaho Division, reduced the maximum grade to 0.5% westbound and 0.4% eastbound. The changes in line which were practically completed on the Union Pacific Ry. in 1904, produced the following improvements (the distance from Echo to Ogden is 40 miles and this line was changed at eight different points, involving the construction of 5.69 miles of new line,:

Location.	—New line— Constructed.	Distance saved.	Saving in curvature.	Maximum grade per mile. Old line.	New line.
	Miles.	Miles.	Degs.	Ft.	Ft.
Archer to Cheyenne....	2.71	0.12	128	40.7	37
Borie to Buford	8.83	0.12	547	91.0	82
Echo to Ogden	5.69	0.05	343	74.0	47
Ellsworth to Dorrance.	1.13	0.06	103	31.0	31

The following statement from the annual report of the Wabash Ry. for the year 1904 also bears upon this subject:

During the past four years the reduction of grades and improvement of the line between St. Louis and Chicago have been under way and are now practically completed, so that trains northbound can be made up for a ruling grade of 21 ft. per mile instead of from 50 to 60 ft. per mile. The cost of the work to date has been $617,300 and the results are as follows:

Curves removed	18
Degree of curvature removed	388° 52′
Length of curved line removed	2¼ miles
Mileage of grades changed	31.3 miles
Line shortened	½ mile
Highway grade crossings removed	9
Railway grade crossings removed	1
Train loads increased from an average of 1,100 tons to	1,850 tons

These works, and the expenditures involved, must not be considered as merely incidental or comparatively unimportant matters. In many cases they are absolutely necessary to enable increased traffic to be handled with safety and economy (as in the case of additional main tracks and passing sidings), and to reduce the cost of operation (as in the case of grade reductions enabling heavier train loads to be handled). A point often disputed in financial circles is the propriety of charging the expenditures of this class of work to capital or to income, but this is a point which we need not discuss. It may be pointed out, however, that (within proper limits) income appropriated to this work instead of to dividends effects an improvement upon the value of the railway property as a whole. The report of the Interstate Commerce Commission for 190[illegible] that in that year the "permanent improvements charged to income account" amounted to [illegible],948,183. A more important matter is the common failure to distinctly separate the expenditures for maintenance and for improvements, the latter being very generally included in the former although they should properly be kept entirely distinct.

It might at first appear that the question of accounting is not one of great importance for the consideration of the engineer, but as a matter of fact it is of considerable importance, in order that he may have a proper record and distribution of the expenses of the work with which he is entrusted. The desirability of a more definite and uniform system of accounting in the expenditures for improvements and betterments has already been referred to, and many of the statements and arguments presented in the editorial on "Railway Maintenance of Way Expenses" in our issue of July 27, 1905, apply equally in this case. In a comprehensive paper on the distinction between repairs and improvements and the classification of maintenance-of-way expenses, Mr. Walter G. Berg, M. Am. Soc. C. E., Chief Engineer of the Lehigh Valley Ry., has advocated a general separation of these expenses into "Repairs" and "Improvements." The former are subdivided into (1) current; (2) contingent; (3) special, and (4) extraordinary repairs. The latter, with which we are now dealing more especially, are subdivided into (a) betterments and (b) additions. It was pointed out in the paper, which was presented at the annual meeting of the American Railway Engineering and Maintenance-of-Way Association in 1904, that the work in both these divisions (repairs and improvements) is grouped in order of its necessity; in case retrenchments are contemplated, the work covered by the first groups is that which must be continued, while that of the other groups may be more readily omitted or discontinued. Thus current repairs (under control of the division engineers and the roadmasters) must be carried on whatever may be the financial conditions; and in the same way some betterments will be made even in times of financial stringency. But the other classes of repairs (especially those extraordinary repairs which involve large renewals or repairs) can be temporarily deferred; and the bulk of the betterment work (and more especially the additions) can be postponed indefinitely without stopping the operation of the railway, although causing a loss of revenue or increased operating expenses. We cannot go fully into the discussion of the subject as presented by Mr. Berg, but we quote his definitions of these classes of work as follows:

The term "improvement" should represent all expenses which create a specific, permanent, physical improvement, tending to increase the value of the railway property as a whole, in the form of a betterment or an addition to the property, subdivided into two groups, according to the following rules:

"Betterments" to consist of any permanent betterments to the existing property and facilities, constituting an actual, distinct, positive, permanent, physical improvement, tending to increase the value of the railway property as a whole; the charge to cover in all cases only the difference in cost of the new improved structure or facility and the estimated cost of replacing the old unimproved structure or facility. The term "betterments" to apply in general to work such as replacing bridges with a more permanent character of materials, strengthening bridges for increased loading, rebuilding buildings, structures, auxiliary appliances and facilities of various kinds on a larger scale and with a better class of materials, increase of track mileage due to rearrangement and remodeling of existing yards and track layouts, stone ballasting etc.; provided, the work in question does not consist merely of extensive remodeling and changing of existing facilities, producing no visible extension or important enlargement of such facilities.

"Additions" to consist of any permanent addition to the existing property and facilities, constituting a distinct, separate, new, permanent, physical improvement, tending to increase the value of the railway property as a whole, such as new roadbed, tracks, bridges, buildings, structures, or other auxiliary appliances and fixtures, etc.; provided such addition or improvement is not in the nature of repairing, renewing, replacing, changing or remodeling any existing facility.

RAILWAY IMPROVEMENTS AND BETTERMENTS IN 1904. (DOLLARS.)

Name of Railways.	Additional main tracks.	Bridges.	Sidings, yards and terminals.	Changes of grade and line.	Total betterments.
	1	2	3	4	5
Atchison, Topeka & Santa Fe	268,621	594,277	.....	1,164,210	8,790,135
Buffalo, Rochester & Pittsburg	528,836	20,425	258,620	.....	913,129
Chesapeake & Ohio	.....	.....	43,302	238,689	538,927
Chicago & Eastern Illinois	260,424	8,340	167,101	5,638	400,121
Chicago, Milwaukee & St. Paul (1)	147,316	765,583	.....	4,780,098	5,914,372
Chicago & Northwestern	1,032,767	509,671	764,265	617,215	3,391,011
Chicago, Burlington & Quincy	.....	.....	329,297	1,532,681	2,054,269
Denver & Rio Grande	.....	159,955	82,783	99,796	591,468
Erie (2)	(See Col. 3)	272,652	1,437,838	44,580	1,995,629
Illinois Central	3,142,700	189,794	566,181	952,752	5,962,900
Louisville & Nashville	80,463	152,081	325,297	.....	1,292,396
Nashville, Cincinnati & St. Louis	.....	50,222	219,898	61,518	471,392
New York Central (3)	(See Col. 4)	1,967,920	1,952,349	1,303,157	7,500,000
Norfolk & Western	1,077,697	186,218	697,881	.....	2,645,306
Northern Pacific	.....	310,000	412,165	479,426	2,050,939
Union Pacific	716,407	805,726	133,833	107,318	3,363,046
Wabash	.....	155,019	620,901	256,442	1,562,299
Total for 17 roads	7,255,221	6,148,483	8,011,701	11,643,520	49,437,339

1. The figures in Col. 2 are for renewing five bridges; three over the Mississippi River. 2. The figures in Col. 3 include main tracks and stations. 3. The figures in Col. 4 include four and double tracking, track depression, elimination of grade crossings, and grade revision.

LETTERS TO THE EDITOR.

Using the Plane Table to Map the Location of Buildings on City Streets.

Sir: I have read with pleasure, in your issue of Aug 17, the various answers to the request of "T. R. Ansit" in regard to the locating of buildings along a street in the course of a town or city survey. To my mind the method of your correspondent who "angles" to the important corners from points along a base line, noting the distances by a tape, is the most practical.

However, it did not seem to occur to any of your correspondents that here are the conditions where a plane table is in its glory. It is evident that the various angles can be taken as quickly and accurately, allowing for all possible error in transit reading, noting and plotting, as with a transit, with the added gain of having the plat made and up to time as you go along, ready for tracing or filing.

The table can be of the simplest design, and the time occupied in setting up and manipulation is much less than that required by a transit.

F. M. G.

Orono, Me., Aug. 19, 1905.

The Salaries of Civil Engineers in the Municipal Service of Manila, P. I.

Sir: The editorial note in Engineering News of Aug. 17 in regard to an article published by the Manila "Cable News," the subject of which was the relative rate of pay of engineers in Manila and Panama, implies a question which I think I can answer. I was in the employ of the Insular Government for about 18 months in 1902 and 1903 (in charge of Timber Tests for the Forestry Bureau) and during that time worked in the city of Manila.

Seven of us, all employees of the Civil Government, formed a "mess" of which I was "steward" and as such handled the funds. At the beginning of each month each put into the general funds $50 gold. This amount was made to cover all household expenses including the rent of a very plain Spanish house in the suburb Ermita, for which we paid $80 gold per month—but did not include any allowance for liquors of any kind. In order to keep the "squeeze" of our Chinese cook at a minimum I personally "did the marketing" and kept a tabulated account of every article "received" and "expended." In addition to the expenses noted it was necessary for each of us to have a native pony and rig, whose keep, including the pay of the inevitable cochero, amounted to $30 gold. Adding to these items smaller necessities and incidentals it is easy to be seen that a salary of $1,200 to $1,400 does not go very far in Manila.

Anticipating the criticism that living in an aristocratic suburb and "sporting a turnout" are rather luxurious habits for an engineer, I would say first that while in my opinion engineers should, more than any class of men, be ready and willing to undergo all necessary hardships and to face every necessary danger I can think of no reason for their encountering either when no good is to be achieved by it; moreover, the manner of living described above is by no means luxury; only a sensible safeguard for one's health. There are cholera, bubonic plague, and, most to be feared, amoebic dysentery to be had in Manila, and the best precautions against all of these are sanitary surroundings and pure, red blood. The former cannot be obtained in the walled city, and to insure the latter one must have boiled water and wholesome food. The military commissary is not open to civil employees and a "civil commissary," which originated while I was in Manila, cannot sell to residents of the city because of the unfair competition it would cause with the local merchants. Consequently the very few local merchants furnish one with wholesome food at prices of their own liking.

No doubt the new electric cars will obviate the necessity for keeping a delicate and expensive native pony; perhaps more merchants will go in to make a livelier competition, but at the very best, living in Manila with anything like the comforts obtainable in the smallest of our home villages, while keeping the chances against a disabling sickness as high, will cost more than double, probably three times, what it costs at home. That the percentage of immunity from disease can be thus raised is evidenced by the fact that none of the seven at this mess had a single day's sickness while living there; not even either dengue or malaria.

I would not be construed as advising young engineers not to accept service in the Philippines. Proposed government work there makes a good probability for an engineer's future and China offers an astounding but very remote possibility, but it certainly would be a justified concession to engineering as a profession and an earnest for the future welfare of the islands to make a "schedule" of salaries at least equal to that of Panama.

Very truly yours,

S. T. Neely, C. E.

Paris, Ky., Aug. 22, 1905.

MUNICIPAL CONTROL OF SMOKE.

When a chimney smokes constantly and seriously, coal is being wasted, and the owner of the plant incurs a regular loss by this waste. At the same time, however, loss occurs in another quarter: the public is inconvenienced and injured by the smoke and suffers extensive damage, pecuniary and other, from depreciation of property, injury to the general health, increased cost of painting buildings, extra cleaning, etc. Both the coal consumer and the public thus have an interest in smoke prevention. If the owner will not for his own sake take steps to reduce his smoke output it becomes the right and duty of the public authorities to intervene and compel him to adopt means for smoke prevention.

The municipal regulation of smoke is in theory a simple question, of purely administrative character. Practically it has proved to be complex and to be rather barren of results, in most of the relatively few cities where it has been tried. For this reason there is interest in a discussion of the administrative problems involved, which was presented last week at the Toledo (Ohio) meeting of the League of American Municipalities by Mr. R. P. King.* The author's experience as Smoke Inspector for his home city makes his remarks authoritative and therefore specially valuable.

The rather common tendency in certain localities to look upon smoke prevention as synonymous with use of anthracite coal is combated at the very outset of Mr. King's exposition. He points out that in most parts of this country anthracite coal is far too costly for general fuel purposes; that the great stores of soft coals in the United States make it necessary to face the wide employment of this fuel to-day and a still wider—practically an exclusive—use of soft coal in the future, as the limited supply of anthracite becomes more reduced. Thus, the problem of smoke prevention will always be with us, and it must be a bituminous coal problem.

The technical solution of the problem is not its serious side. Speaking generally, it may be said that no case of the smoke evil exists where the expert on fuel and combustion cannot bring relief. The serious side of the matter is that thousands of coal users will not seek this relief, and cheerfully continue to oppress their neighbors by smoke. General apathy toward the purposes and methods of smoke prevention cooperates with this fact in making the administrative problem a difficult one. As Mr. King says, owners look upon compliance with smoke ordinances as a hardship to be met with the least possible expense. The author's review of the subject of municipal smoke prevention should therefore prove interesting to many. It is given with but slight condensation, as follows:

When framing a smoke ordinance we must assume that it has some good basis for its being; for in order to successfully withstand contested cases it must be authorized by some sound legislative enactment, otherwise it would fail. Starting at this point, the framing of the ordinance has much to do with the success of its future enforcement. The ordinance should:

(1) Declare smoke a nuisance.
(2) Fix the responsibility for violation.
(3) Fix the authority and duties of those having charge of its enforcement.
(4) Contain an alteration clause.
(5) Provide a permit clause and fix fees.
(6) Provide a penalty.

In fixing the responsibility the burden should be divided. The burden of originally making the plant a non-smoker should be on the owner; that of keeping the apparatus in repair should be on the employee. The authority of the smoke department should be definitely fixed, but their duties should be outlined in a general way only. It seems to the writer that the alteration clause is the best way of primarily attacking the problem. In this case a certain time is given during which time the plants are supposed to be changed. With a permit clause in effect this will give the chief of the corps an opportunity to watch conditions and collect data before prosecutions are in order. In fixing the fees, $5 for new installations and $2 for repairs seems to be the usual charge for each boiler.

The Chicago ordinance places the alteration limit at one year, which time of course had to elapse before any advance was made. This ordinance is included in a steam boiler ordinance and the enforcement of both is in one department, which seems a very happy combination. This ordinance is particularly strong on fees, dividing them with great precision. The Milwaukee ordinance contains no alteration clause, making the owner liable immediately upon the passage of the ordinance. It also lays down with considerable minuteness the duties and qualifications of the smoke inspector. The amended Cleveland ordinance is modeled after the Indianapolis ordinance with the exception of omitting the duties of the inspector and changing the name to Supervising Engineer. The Indianapolis ordinance, instead of providing an alteration clause, makes it the duty of the smoke inspector to inspect each plant, point out the cause of the smoke, make recommendations and set a time for changes, the limits of which are laid down by the ordinance. There are very few smoke ordinances that have not been amended since their passage, which shows that the best laid schemes sometimes fail to carry out.

The personnel of the department is of great importance as the suppression of smoke is in reality an engineering work of no small magnitude. The work of collecting data, ordering changes, supervising new work and instructions requires a man of technical and executive training. He should be competent to conduct tests and to make analyses, be of wide practical experience, diplomatic to a degree, and of unimpeachable integrity. His title should be that of engineer and his position must be one of dignity. Such a man can command an ample salary and a corresponding one should be attached to his municipal position. Under him should be a practical fireman familiar with the care and operation of the various smoke presenting devices in use. The work of making charts, photographs, prosecutions, etc., may be acceptably done by any one having received a certain amount of instructions.

The department should be located in commodious quarters and equipped with all necessary apparatus. This will include draft gages, pyrometers, indicators and analytical apparatus. For measuring draft the U-tube is commonly used and is sufficient for any but the more refined work. For measuring the furnace draft a Barrus gage is acceptable, although the furnace draft may be tested by means of a candle flame, while an open handkerchief makes a reasonably accurate gage for testing the ash pit draft. Thermometers may be used for temperatures to 1,000° F. and may be carried by inspectors at all times. For continued measurements an electric pyrometer is used which is reasonably portable and may be used to 3,000° F. The Orsat apparatus is generally used to make flue-gas analyses and as it is reasonably portable may be carried from place to place as necessary. For coal and water analyses other apparatus of a purely chemical nature is required.

The writer has never found any reliable data concerning the steam plants visited and inspected. Many employees do not know the sizes of the boilers under their charge: Coal consumption is a thing to be guessed at monthly coal bills being the best information obtainable. I know of but one plant in Indianapolis that keeps a daily record of coal burned and not a single instance of a reliable and complete log being kept. I have spent much time compiling data and conducting tests with the sole idea of providing for the steam users of Indianapolis reliable data upon which to base future calculations. The following recommendations are partly the result of these tests:

When designing or altering furnaces the following general rules should be observed:
(a) Minimum height of chimney 75 ft. (when chimney sets on smoke box; allow extra height to compensate for losses in horizontal flues and right angle bends.)
(b) Allow 5 lbs. coal per rated horse power.
(c) Estimate the grate area on a consumption of not less than 20 lbs. coal per hour per square foot. This gives for a 100-HP. boiler 25 sq. ft. of grate area. If possible increase the draft to reduce this area to 20 ft.
(d) Vary the grate area for boilers in the same battery, increasing this area as the distance from the chimney increases.
(e) The following ratios are approximate, but are in accordance with the above rules.

Grate area to heating surface, from 1:45 to 1:60.
Grate area to area over bridge wall, 5:1.
Grate area to area across tubes, 6:1.
Grate area to area across breeching, 6:1.
Grate area to chimney area, 7:1.

I found the best results with bituminous coal to be when running with a high rate of combustion. A hot fire can only be produced by a high rate of combustion and a hot fire is the only smoke preventing condition. Our department recommends a rate of not less than 20 lbs. per sq. ft., while 30 lbs. is excellent; get 40 lbs. if you have the draft. Under these conditions smoke prevention is possible and economy is assured.

The collected data of the department should be given at times to the steam users, through the medium of bulletins. Several smoke departments are using this means of education. The bulletins should be short, not too technical and to the point. The newspapers may be of great assistance in a smoke campaign, but this help sometimes is of doubtful character. If their artillery could be brought to bear on the people that make the smoke instead of worrying those that are trying to prevent it, more real good might be done. But by all means advertise the work through the newspapers, for it makes the people talk, if nothing else.

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Manufactures are the life of most of our smoky cities and to antagonize them needlessly means ruin to the interests of that city. As mercy should temper justice so common sense should leaven the work of the smoke inspector. Here is an enterprise in the hands of a receiver with labor with the receiver to buy better coal. What else can be done? The court cannot be sued. A large plant was offending badly. It was a large, ultra-municipal corporation. The matter of improvement was taken up through the firm that made the devices in use and the plant cleaned up in a month without suit or hard feelings.

Of course all cases cannot be handled by diplomacy, and for such there is the heavy hand of the law. In collecting the evidence for prosecutions the best way to illustrate the condition is by charts. On these charts vertical spaces represent degrees of density of smoke and horizontal spaces represent time. By this means a continuous record may be presented to the court, which may be supplemented by photographs. I have never had evidence of this character disputed. Appealed cases are more difficult for there enters in the question of legality of the law, reality of the nuisance and possibility of complying with the law. These points are not, however, difficult to prove.

In attempting to comply with the letter of the law, owners advance all sorts of wild ideas that have been tried and modified for years. With these may be classed a large number of fake devices that have not proven satisfactory to any one except the contractor. For experimental work, the writer requires detail drawings and in some cases where the device resembles a perpetual motion machine, a mathematical demonstration. These usually serve to head off the fake. An unsuccessful device once installed is worse than none at all and an attempt should be made to make every installation a complete success.

Of the successful devices there are four classes: (1) Steam jets; (2) Furnaces; (3) Mechanical stokers; (4) Smokeless coal.

Steam jets are an uncertain quantity and while eminently successful in certain plants, for some unaccountable reason the same machine fails in others. In order to be of value the steam jet must meet certain requirements: It must be correctly installed; it must be automatic in action, and it must admit a sufficiency of air at the instant of firing. Steam jets are not adapted for boilers larger than 125 HP. nor should they be used when more than three boilers are connected to one chimney.

When properly designed the smokeless furnace gives smokeless combustion and a high efficiency. One peculiarity of these installations is that the harder they are pushed the nearer smokeless they become. Their successful action depends on a high furnace temperature and to that end the grate area must be reduced and the draft increased; the fire box must also be roofed in with fire brick. It is not unusual to maintain a rate of 30 lbs. per sq. ft. of grate in these furnaces.

Of successful stokers there are four general classes. The underfeed, in which the coal is forced up under the fire, has been successful with cheap coal. The system uses a forced draft and by means of automatic regulation the air may be shut off allowing the coal to coke in the furnace. Then, by increasing the air supply, steam can be generated very rapidly, thus meeting the condition of a fluctuating load. The limit of combustion of an underfeed stoker may be placed at 1,000 lbs. per stoker per hour.

The inclined grate stoker class may be divided. The most successful is the rearwardly inclined stoker, in which the coal is fed into a hopper and then forced by gravity forward over a series of steps. This stoker can be built in all sizes, will stand hard usage and owing to the positive feed and adjustable stroke of the pusher plate can be forced more rapidly than some other makes of stokers. To be successful as a smoke preventative it should be equipped with steam jets and must be carefully handled. This type is a very popular stoker for electric power plants. The side inclined stoker differs from the above in that the magazines are along the sides of the furnace and the coal is slid along plain inclines instead of steps. This type is not adapted to large boilers, owing to the space on the sides taken up by the magazines.

Of the traveling grate type there are many stokers built along the same lines, differing only in minor details. These stokers are the most successful smoke preventers but are not adapted to fluctuating loads. There is also a tendency when firing heavily to run the fire over the back of the grate. To remedy this, one firm has placed a dump grate at the back which holds any surplus fire until it is consumed.

There is little to be said about smokeless coal as the field has been thrashed from one end to the other by our eminent authorities. In the soft coal regions the use of smokeless coal should be limited to residences. In Indianapolis, for instance, smokeless coal has no business under a steam boiler as our cheap native product can beat it 2 to 1 owing to the difference in heat that can be bought for the same price.

The shaker grate has a field in the soft coal district. With a small grate and a high rate of combustion, a shaker grate is necessary and should be used in all furnaces burning bituminous coal.

While the rotary grate stoker is yet in the experimental stage, it seems to fill a need for cheap stoker or small installations. As the name implies the grate is round, revolving bodily and coal is blown in with a steam jet.

The economy of smoke prevention is a well demonstrated fact. For instance, a smokeless furnace reduced a certain coal bill 65%, bringing the cost of 1,000 lbs. of steam to 10½ cts.; this with coal delivered by wagon to a very small plant. Another firm with stoker equipment and track in the boiler room gets 1,000 lbs. of steam for less than 9 cts. A large power plant fully equipped with stokers gets the cost of power down to less than ⅛ cent per KW.-hr.

The Cleveland department of smoke abatement has issued a pamphlet on boiler economy to the steam users of that city. There the campaign is one of education solely and the results that have been attained there are due entirely to a desire to save money. In Chicago the campaign has been one of prosecution, although the amended Chicago ordinance is more one of education than formerly. Chicago and Cleveland are the two most notable examples of clean cities in the soft coal districts. With opposite methods it may be mentioned that Cleveland has made the best showing.

To briefly review the works that touch on this subject will require only a moment. "Steam Boiler Economy," by Wm. Kent, is the most complete work on the subject, but unfortunately says little on smoke prevention except in a general way. The book contains valuable information on coal and boiler efficiency but the practice is for the most part on eastern coal. "Engineering Chemistry," by Thos. Stillson, is a most valuable book on quantitative analysis, and while nothing is said about smoke prevention the book is invaluable to one handling [illegible] used in this work. Barr, in his "Prevention [illegible] deals principally with the prevention of smoke [illegible] tive practice, advocating the fire brick for [illegible] boiler. The book "Mechanical Draft," edited [illegible] B. Snow and published by the B. F. Sturtevant [illegible] one of the best books on combustion known to [illegible] It gives greater attention to the burning of [illegible] coal, and the principles laid down there are [illegible] true ones. Mr. Snow is, like the writer, conversant [illegible] marine practice and advocates following this [illegible] land work. The Stirling Co. has recently brought [illegible] book on steam, which supplements the work of [illegible] the two making a very complete treatise on steam [illegible] economy. The "Book on Steam for Engineers" [illegible] reliable data on coal with charts and other [illegible] valuable to steam users. The Babcock & Wilcox [illegible] "Steam" has been reprinted and quoted for years [illegible] lates chiefly to water tube boiler practice and [illegible] ples and practice of burning anthracite coal. His [illegible] book "Coal is King" gives the most complete [illegible] coal analyses on record. The book is valuable [illegible] the analyses of western coal. The catalogues [illegible] making stokers all contain more or less information [illegible] coal and methods of burning the same. Analyses [illegible] from these catalogues are not to be credited unless [illegible] are the work of some recognized authority.

The current engineering papers publish from time to time valuable information on coal burning. The proceedings of the American Society of Mechanical Engineers is a mine of information on this subject. The proceedings of local engineering clubs also contain much valuable matter.

A UNIT FRAME REINFORCEMENT SYSTEM OF CONCRETE-STEEL CONSTRUCTION.

The reinforcement of concrete girders consists of bent and straight bars and stirrups arranged in definite positions with respect to each other and to the presumed shearing and tension stresses in the girder. It is the most common practice to put these bars and stirrups in place separately and one at a time as the concreting progresses. This mode of procedure requires great care and vigilant inspection to make sure that the reinforcing units are accurately spaced and alined when being placed and are kept in their true positions during the deposition tamping and hardening of the embedding concrete. To reduce the chances of error in these respects it has been proposed by a number of designers so to connect up the various bars and stirrups as to form a reinforcing frame which could be handled and placed in the work as a single unit. The drawings accompanying this article illustrate one of these unit frame reinforcements for concrete girder and floor construction.

Details of a heavy girder showing the reinforcement in place are given in Fig. 1. The main reinforcing bars are of special construction; they are rolled in groups of four bars with connecting webs as shown by Fig. 2. After being rolled the

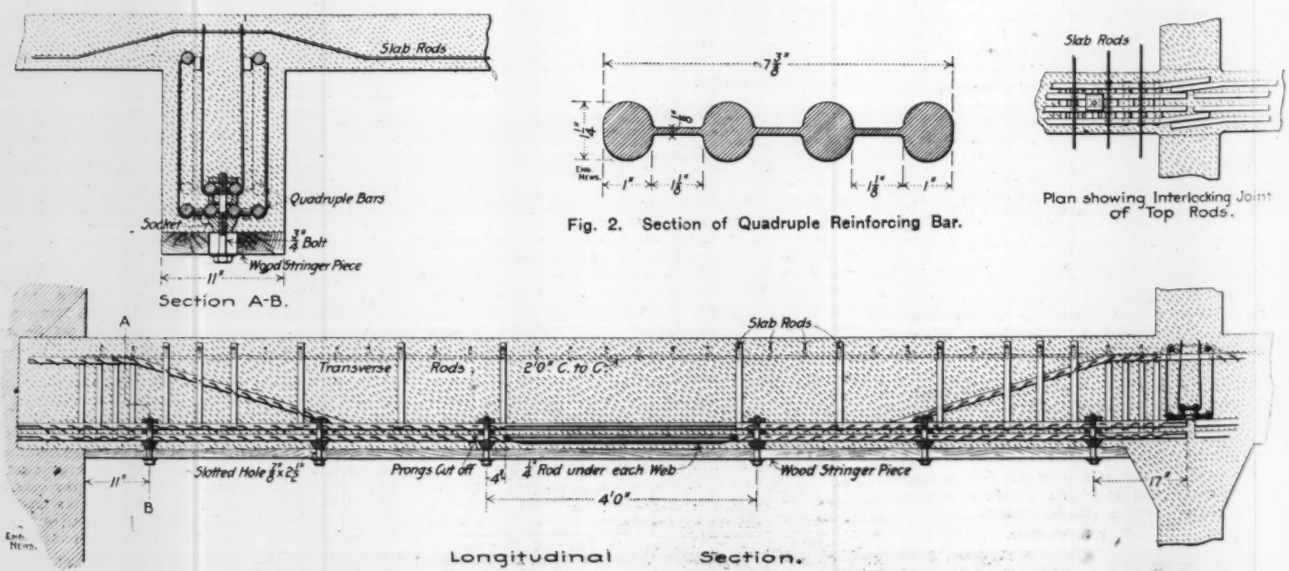

FIG. 1. GIRDER REINFORCED WITH UNIT REINFORCING FRAME OF QUADRUPLE BARS.

Fig. 2. Section of Quadruple Reinforcing Bar.

Plan showing Interlocking Joint of Top Rods.

set of ... is placed in a punching press which cuts ... gular slots in the webs at 3-in. inter-vals. ... web metal at these slots is not re-moved ... is cut through on three sides of the rectal... nd bent down so as to form an ear or pr... nnected to the solid web on the fourth side. ... rawings of Fig. 1 indicate this detail.

In ... am shown in this drawing there are two s... four bars placed one above the other. The b... the bottom set are all straight; in the top se... e two intermediate bars are straight and t... o outside bars are bent up for about one-th... their length at each end. Along the

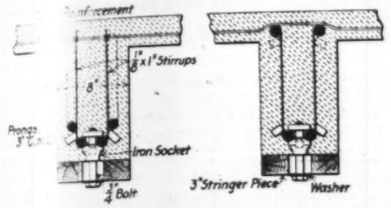

Fig. 3. Sections of Girder Reinforced with Single Quadruple Bar Frame.

bent up portions of the bar the web is sheared through after punching so as to disconnect the outside bar and adjacent intermediate bar and leave the prongs on the outside bar. It will be noticed also that the web in the middle portion of each set of bars is not punched. This gives the full section to resist tension at the middle of the beam, but requires the use of hanging rods to give the concrete bond with the steel of the lower bars. For lighter beams only one set of bars is used, as shown by Fig. 3. The bar sections shown in Fig. 2 are also made of various weights to suit different loadings.

To form the unit frame the two sets of bars shown in Fig. 1 are clamped together rigidly by clamps constructed as shown by Figs. 4 and 5. These clamps also serve to space the reinforcement the proper distance above the bottom of the beam and for attaching a stringer piece for the attachment of shaft hangers. The stirrups are looped through the slot holes and fastened by hammering the prongs tight against them. They have slotted holes at the top through which is threaded the floor slab reinforcement.

In construction, the forms for a complete floor are erected; the girder reinforcement is then placed a unit at a time until it is complete for the

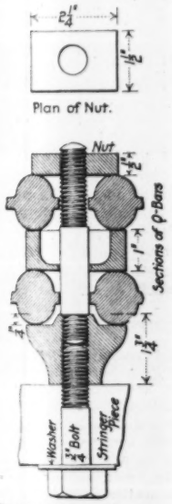

Fig. 4. Clamp for Double Quadruple Bar Frame.

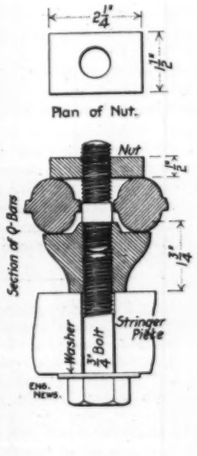

Fig. 5. Clamp for Single Quadruple Bar Frame.

whole floor. In this shape inspection is possible. The concrete is then placed in the usual manner.

A full size floor unit of this system of construction was subjected to a fire and water test on June 16 and 17, 1905. The test was conducted by the engineering staffs of the Building Bureaus of the cities of New York and Philadelphia, directed by Professor Ira H. Woolson, of Columbia University, New York, assisted by two students of the University.

The test house, or furnace, was a brick building, 10 ft. 6 ins. wide by 19 ft. 6 ins. long, inside. The clear height from the ground to the bottom of the beams was 10 ft. 6 ins. The roof consisted of three concrete beams, 14 ins. deep, spaced 4 ft. center to center, two beams resting at the ends on 12 × 12-in. reinforced concrete columns. The middle beams rested on 11 × 16-in. reinforced girders, which in turn were supported by the columns. The slab was 3 ins. thick.

The columns were reinforced with four ⅞-in. rods tied together every 18 ins. with ¼-in. wire ties. The beams were reinforced with girder frames made up in three different manners. The 11 × 14-in. beam was reinforced with a girder frame made of ¾-in. patented quadruple bar, with ⅛ by 1-in. stirrups secured to the bar at intervals of about 12 ins., except at the ends, where they were closer, by means of the prongs struck out of the webs. The middle beam was 9 ins. wide and 14 ins. deep, reinforced with four 13-16-in. round steel rods clamped together with ⅛ × 1-in. stirrups spaced as in the other beams. The remaining beam was the same size as the middle beam, reinforced with two patented Siamese bars punched their entire length with stirrups clinched thereto by means of the prongs thus formed and spaced the same as in the other beams. The slab was reinforced with 5-16-in. plain, round rods run at right angles to the beams, spaced every 6-in., with 5-16-in. round rods run at right angles thereto about two feet. Additional short rods, 5-16-in. in diameter were run near the top of the slab over each beam to reinforce this portion and passed through holes in the stirrups. The distance from center to center of the columns was 16 ft. The beams were continuous over the columns, and rested in the end walls. The concrete was hand mixed: one part of Vulcanite cement, two parts of Jersey bank gravel, four parts of trap rock, ½ and ¾-in. size. The steel had an ultimate strength of 60,000 to 70,000 lbs. per sq. in. The concrete was two months old.

The test slab and beams were to carry a total live load of 30,700 lbs. during the fire test and 122,800 lbs. the following day. The average temperature of the fire during the test was 1,708.6° F. The maximum deflection of the middle beam under the action of the fire and water was 1 27-32 in. On June 17, under the full load of 650 lbs. per sq. ft., which by an error was 50 lbs. more than the requirements, the deflection was only 2 ins., which was 1 in. within the deflection allowed by the department.

When the total load was removed some two weeks afterwards, it was noticed that the beams had recovered ¾-in. of the deflection, showing that the elastic quality of the construction had not been destroyed. The effect of the water under the high velocity and pressure was to cause some of the concrete on the other side of the beams to spall off. The concrete on the girders, columns and slab was undisturbed except for the small spalling of a corner of one of the columns. An interesting fact developed by the test was the expansion of the four columns from heat. They elongated about one inch and recovered their normal position in cooling.

The unit frame reinforcement described above is patented by the Unit Concrete Steel Frame Co., of Philadelphia, Pa., to whom we are indebted for the matter from which this description has been prepared.

THE USE OF COPPER to render dangerous water safe for drinking has frequently been referred to of late as an ancient practice in the Far East. Some interesting recommendations on this point, taken from Sanskrit writings, are cited in a letter written to the (British) "Journal of Preventive Medicine," by Francis Evelyn Place, B. Sc., of Jaipur, Rajputana, India. We quote from the letter as follows:

In the "Ousruta Sanghita"—a collection of medical lore in Sanskrit, probable date 2000 B. C., chap. xiv., verse 15—appears this instruction: "It is good to keep water in copper vessels, to expose it to sunlight, and filter through charcoal."

In the "Neghrund Bhusan"—a collection of medical maxims from the "Ayura Veda," the earliest Sanskrit work on medicine extant, of about the same date—in the chapter on water, in the last sloka but two, it is directed to treat foul water by boiling and exposing to sunlight and by dipping seven times into it a piece of hot copper, then to filter and cool in an earthen vessel. The direction is given by the god who is the incarnation of medical science.

THE MANUFACTURE AND USE OF CONCRETE BLOCKS.

By F. W. Hagloch.*

Concrete blocks, both hollow and solid, are comparatively ancient inventions. Mr. Obediah Parker, of New York, made and used solid cement and composition building blocks, and was granted a patent covering his process of construction in 1835, and Mr. Parker may, I believe, be justly styled the father of the artificial stone industry. Mr. Joseph Gibbs, a civil engineer of London, England, made hollow building blocks of sand, cement and broken stone with the use of a mold of his own invention, which consisted of lattices, removable cones and pallets. Mr. Thomas Heap, of St. Joseph, Mo., built walls in 1868 with hollow concrete blocks of his own manufacture, and such work of his as remains is apparently solid to-day as any natural stone used in the same city. Mr. Thomas B. Rhodes, of Lebanon, Ohio, made hollow concrete blocks in 1873 and 1874, and fully 60% of the hollow blocks of the present day show the influence of Mr. Rhodes' original ideas. In 1876, William Johnson, of Brooklyn, N. Y., made and exhibited hollow concrete blocks at the Philadelphia Centennial Exhibition. This exhibit inspired builders to such an extent that in 1880 over 40 patents were granted in the United States, England and France for as many different styles of hollow concrete blocks. To-day the patent records of these countries contain drawings and descriptions of over 1,600 different styles and processes of making hollow blocks and artificial stone.

MATERIAL.

The selection of material is the first important step in the manufacture of artificial stone and a description of the process will not come amiss.

CEMENT.—Cement used in artificial stone and hollow blocks must be sound (non-expansive) and burnt to a sufficient degree of heat to insure adhesiveness, and also be ground to fine dust, as the finer the cement, the greater the quantity of sand and aggregates that can be used and maintain a given strength. The color of cement has little to do with its quality; bluish colored cement is usually burned to a low degree, but there are great exceptions to this rule; light colored cements are usually high burnt, but there are also exceptions as a low grade cement in which lime predominates, or which is mixed with furnace slag is also very light in color. Eight years' experience has taught me that cement containing more than 68% of lime should not be used in making artificial stone or hollow blocks, and cements containing less than 52% of lime are also unfit. Cement made of or containing furnace slag can be used successfully only in constantly damp places, and is therefore unfit for hollow blocks exposed to the elements as they become brittle in from four weeks to six months. I am sorry to note that several high grade American cements have in the past year contained furnace slag in small quantities, which has compelled me to condemn their products in the manufacture of artificial stone.

Laboratory tests of cement are expensive and require 28 days which causes great delay to the average hollow block maker, hence I shall give a few simple rules by which anyone of ordinary knowledge of cement may test any cement in a few days' time. To know whether a cement is sound, fill an ordinary lamp chimney with dry cement, pack the same well and add water, which is perhaps best done by placing the same in a vessel and filling the vessel with water. If the cement contains free lime or inert particles, it will in from 6 to 18 hours expand sufficiently to break the lamp chimney; the breaking of the chimney is sufficient evidence that the cement is unfit for use. The setting of cement may be readily tested by mixing it with sand and aggregates in the proportion it is intended to be used; mix with water and fill a teacup, place the same where it will be free from air drafts and sunlight, keeping it damp for 24 hours. At the end of that time, if the mass has no check marks on its surface and has set sufficiently to be easily removed, it is a safe cement to use, but check marks, blisters or failure to set in that length of time is sufficient evidence to condemn it.

*Consulting Engineer, Cuyahoga Building, Cleveland, Ohio.

SAND.—More care is required in selecting sand for artificial stone work than for ordinary concrete. Sand does not necessarily need to be sharp, but it must be clean. Sharp sand is far superior, however, to round grain sand. The impression that sand of uniform sized grains makes the strongest work is wrong. Experience has proven that the greatest strength with the least possible cement is obtained by the rescreening of sand in different sized mesh sieves and using equal proportions of the different sized grains, as this mixture has the least possible voids. Sharp silica sand is always preferable; this is best obtained by crushing silica stone, thus producing a clean article. Bar sand is nearly always clean and can be used in its original state. Bank sand varies in cleanliness and is rarely ever free from dirt. There are various systems of testing and examining sand. Sand can best be examined with a small lens (microscope), with which coarse particles and the sharpness of the grains can readily be seen. Foreign particles are nearly always of the dust nature in dry sand, and can generally be detected by rubbing sand in the hand, thus freeing the dust from the grain. This same defect may also be discovered in wet sand by molding the sand into a small pat in a cloth or the palm of the hand, the compression wringing out the moisture. The water wrung from the pat will be discolored to the extent of the foreign substances.

AGGREGATES.—Gravel is the most commonly used aggregate, but crushed limestone, furnace slag and brickbats are often substituted with good results. All aggregates should be washed and dried before mixing with sand and cement. In concrete work it is preferable to have the aggregates damp, which is not objectionable in artificial stone work, except where smooth facing or ornamental work is desired. Crushed limestone is not to be recommended from the fact that it has a tendency to expand and contract in the absorption and expulsion of moisture. The Stevens cast stone process, as well as several others using crushed limestone in large proportions, have much difficulty with crazing, which is almost always attributed to quick drying. Experience has taught us that it is due to the expansion and contraction of the stone particles.

Furnace slag is an admirable aggregate, but owing to its porous nature it consumes much cement, especially when high grade, fine ground cement is used. Slag makes perhaps the lightest weight artificial stone of any aggregate. Cinders, when washed free from small particles, may be used, but are not desirable where fine and uniform faced stone is desired. Brickbats when soft are unfit for concrete work, and are rarely ever sound enough for making stone of high crushing strength, such as are required for foundations.

Crushed stone that absorb little water are perhaps the best aggregates for concrete where great tensile strength is desired. For this purpose limestone has in the past eight years been extensively used, and it is recognized to be superior to any other aggregate in many localities. Careful investigation has proven that soft limestone which absorbs water freely makes weaker concrete than gravel, cinders or concrete without aggregate, which is caused by the limestone expanding by the absorption of water and the contraction in drying. Experience has taught us that hard sandstone, crushed to a size of 1 in. in diameter, will equal any other aggregate in both tensile and crushing strength, except furnace slag, which has great tensile strength, but owing to its porous nature requires a greater proportion of cement than any other aggregate. It should be remembered that soft sandstone is unfit for aggregate and should never be used. In a recent test of concrete construction blue sandstone aggregates far excelled both limestone and furnace slag aggregates in crushing strength and stood second in tensile strength, concrete with furnace slag aggregate having the greatest tensile strength.

Cinders can be used as the aggregate, but must be washed free from dust and foreign particles, and afterwards screened with a screen of four meshes to the inch, using only such particles as do not pass through the screen. In the selection of cinders as an aggregate care should be taken to get only hard cinders.

PROPORTIONING.

One of the principal difficulties in artificial stone making and concrete construction is the determining of the proportions of sand, cement and aggregate. Nearly all authorities on this subject recommend that proportions be made by weight in preference to measure. These authorities are basing all their calculations on the use of dry sand and aggregates. Experience has proven that there is not one instance in a hundred where such conditions exist, therefore weight proportions can not be relied upon; nothing is as positive or so good a guarantee of uniformity of strength and color as measuring where sand and aggregates vary in moisture and a uniform brand of cement is used. The following example will do much to make this clear in the mind of the reader. Dry sand upon the addition of 15% of its own weight in moisture will not increase in bulk. Gravel will act the same up to 8 or 10% of moisture and some crushed limestones will carry 35% of its weight in moisture, while increasing only 4 to 5% in bulk. Are not these facts sufficient to show the inconsistency of proportioning by weight where sand and aggregates are perpetually increasing and decreasing in weight when exposed to the elements? This is one of the many instances in artificial stone work where theory is exploded by a little common sense practically applied. To more clearly demonstrate the fact the following calculations are given:

To make stone of one part cement, two parts sand and three parts aggregate, take 100 lbs. cement, 200 lbs. dry sand and 300 lbs. crushed stone. Let the sand and crushed stone absorb all the moisture possible without making them drenching wet, and measure by weight as before; the proportions will be: cement, 100 lbs.; sand, 165 lbs.; crushed stone, 200 lbs. In proportioning the above by measure, you would have almost the rame ratio under the different conditions.

Dry sand and aggregates are always preferable and where such can be had the weight measure is the most accurate, but in most instances they cannot be had, and the formulas given in this work are all by measurement except in the case of the addition of coloring matter, and where this is done on a large scale we would recommend measure by weight.

A formula will only produce the same product under the same conditions. It is, therefore, impossible to establish a formula that will give the same results everywhere; the following are special formulas which if followed will make good work possible with a little experience. The amount of water to be used is omitted from these formulas, this being fully treated in the section on mixing.

ARTIFICIAL STONE.—A composition that will produce waterproof artificial stone, hollow concrete building blocks, etc., varies with the sand and aggregates used and special experiments should be made. In the following formula sufficient cement is given so that they may be followed with safety, but cost could in many instances be reduced by having a knowledge of the exact conditions: cement one part, sand two parts, gravel, ½-in. in diameter or less, three parts. Another formula now extensively used is, cement one part, sand two parts, crushed limestone or cinders, ½-in. in diameter or less, two parts. Where smoothness of surface is an object and strength is very essential, the following will invariably prove satisfactory: one part cement, one part fine sand, one part coarse sand, one part gravel or crushed stone of ¼-in. diameter or less. These formulas will be found excellent in making ornamental work, except where fine moldings or fine letters are intended, in all such cases the gravel should be omitted.

WHITE STONE.—Pure white is impossible where great strength and durability is required, but the following formula will make white stone stronger than Cleveland sandstone. Nothing but white Portland cement can be used. The most reliable brands are the following: Aetna, Dragon, Giant, Nazareth, Phoenix, Vulcanite, Whitehall and several others. One part pulverized lime or limoid, two parts Portland cement, two parts pulverized marble, two parts fine washed silica sand, two parts coarse washed silica sand.

STEEL BLUE.*—This color is often obtained without the addition of any coloring matter by the use of bluish colored cement, proportioned as follows: one part Diamond cement, three parts sand, two parts small gravel. Light colored Portland cement can be blended to its proper color by the addition of 7 lbs. Ultra Marine blue to every barrel of cement. Should the sand be of a dark or brown color, increase the Ultra Marine blue up to 10 lbs. per barrel of cement.

GRAY.—Add 2 lbs. of Germantown lampblack to every barrel of cement when sand is of light color; dark sand may compel the decrease in the lampblack. Lampblack is a protector against the elements, but reduces the strength of the product; in ordinary dwelling house construction this is an admirable feature, but in the construction of buildings where great resistance of crushing is desired it would be advisable to sacrifice color by the omission of the lampblack.

BLACK.—To every barrel of cement add from 40 to 50 lbs. peroxide of manganese.

LAKE SUPERIOR RED STONE.—Much depends upon the color of sand and aggregates in imitating this stone, but with little experience by the addition of about 20 lbs. of violet oxide of iron to every barrel of cement it can be done; light sand requires more, dark sand less coloring matter.

BEDFORD, INDIANA, BUFF STONE.—In making buff stone ochre must be used, which is always detrimental to cement work, reducing its strength, and when used in large proportions causing disintegration; 12 to 15 lbs. of yellow ochre to every barrel of Portland cement will with the average colored sand produce an exact imitation of Bedford Buff Stone.

CONNECTICUT BROWNSTONE.—Twelve to 15 lbs. of brown ochre to every barrel of cement.

In making all colored work nothing but clean sand and aggregates should be used. Where they cannot be had in a natural state, thoroughly wash by placing them on a large platform or floor and applying the hose; dry before using.

CURING CONCRETE BLOCKS.

Blocks made by the dry or machine process require great care in curing (hardening), which is best done by keeping the blocks continually moist for a period of six or eight days, at the same time the block must be kept from the sunlight and air drafts. I have given this part of hollow block making much study during the past year, and I find that applying a light spray of water as many as 12 or 15 times per day is the best method, as stone cured in this way is almost as hard as granite. Hollow blocks made in this way will be ready for use in 15 or 20 days and solid stone will require four or five days more. Stone made by the wet process, known as the pouring method, may be used earlier and require less care in being kept damp. Ornamental work requires more time to harden owing to the uneven thickness and too much care cannot be taken. Coverings made of burlap and carpet, dampened and applied a few hours after molding, have proven excellent and inexpensive modes of curing such work.

SOUNDING AT GREAT DEPTHS is accomplished in a novel way by a method originated by a Norwegian engineer, Berggraf. It utilizes the fact that sound traveling downward through the water is reflected upward by the bottom, and the fact that the time between a sound and its echo is a measure of the distance traversed by the sound waves. A vessel is equipped on one side with a sound transmitting device, below the water, and on the other side with a sound receiver in similar position, the membranes of both devices facing down. A sound is sent out by the transmitter, and simultaneously a stop-watch device is started; when the echo reaches the receiver, the motion of this device is stopped, and the elapsed time then represents to a scale the depth of water under the ship. A recording device can be arranged in conjunction with this apparatus to give a continuous record of the depths thus observed.

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*In the formulas for making various colored stone we recommend that colors be mixed with cement separately before adding to the cement the other materials unless otherwise specified.

NEW FORMS OF CHARGING AND DISCHARGING MACHINES FOR GAS RETORTS.

A novel charging machine has recently been described as a solution of the problem of rapidly and cheaply charging coal into gas-works retorts. It is based on the substitution of ballistic action (and hence rapid motion) for pressure applied by slow-moving parts. This principle permitted the direct application of an electric motor, and resulted in a light and compact machine.

The accompanying photograph, Fig. 1, shows the device quite clearly. In the view, the machine hangs from a small overhead traveler running on a track along the front of the retorts. The large wheel at the left has a wide grooved rim, on which runs a belt passing over an idle pulley at the top, a driving pulley at the extreme left below, and an idler for the return side of the belt. The forward driving pulley is itself driven by belt from an electric motor set at the back end of the machine. At the top of the machine is a hopper, whose mouth is directly over the point where the wide belt approaches vertically the grooved rim of the wheel.

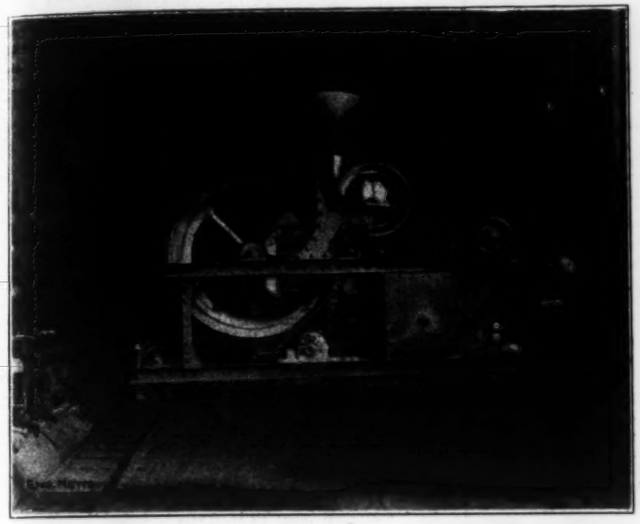

FIG. 1. BELGIAN BALLISTIC CHARGING MACHINE FOR GAS RETORTS.

In operation, the belt runs at high speed downward and forward on the large wheel. Coal falls from the hopper into the space between the grooved wheel and the belt, and is carried around the curve of the wheel, being gradually accelerated to the speed of the belt. When the coal reaches the lowest point of the wheel it continues horizontally forward, lying on the top of the belt, and finally is projected out horizontally where the belt passes over the driving pulley. The speed of the belt and the angle of elevation of the machine are so adjusted that the coal is thrown into the open front end of the retort to the back end. The retort is thus completely and compactly filled. A 20-ft. retort is charged in a few seconds. Three retorts can be charged in a total time of 1 minute by one person operating the machine.

The machine was invented by Mr. De Brouwer, superintendent of the Bruges (Belgium) gas works, and has been in use at those works for some time, with very satisfactory results, as we are informed by a correspondent. The machine is fitted with a 4-HP. motor, driving the large wheel at a speed of about 200 r. p. m. (in case of a 10-ft. retort), which imparts a velocity of about 2,000 ft. per min. to the coal. The use of the machine has resulted in much saving of labor. It has been found, also, that the accumulation of graphitic residue in the retorts is reduced, so that cleaning need now be done only once in six months. Simplicity, economy, low first cost and low operating cost, reliability and adaptability to all types of gas plants are claimed for the machine.

FIG. 2. FRENCH BALLISTIC CHARGING MACHINE FOR GAS RETORTS.

Another form of ballistic charging machine, which utilizes the same principle in a different manner, is in use at the La Villette plant of the Paris Gas Co. In this machine the coal is thrown by the centrifugal action of a small fan-wheel mounted on a vertical shaft at the rear end of a nozzle-tube.

Fig. 2 shows the machine complete. A hopper of about four tons capacity, at the top of the framework, feeds coal to the fan-wheel through a vertical telescoping tube. The fan is a four-bladed wheel about 28 ins. in diameter. A nozzle-tube projects tangentially from the fan-casing to within a few inches of the front of the retorts. Fan and nozzle-tube can be raised or lowered by electric motor power, so as to bring the tube squarely in front of any retort, the vertical chute from the hopper being of telescoping construction to permit this. The entire machine is traversed along the bench by a motor which rolls the machine along a rail track as indicated in the view. A 12-HP. motor does the traversing, and also drives a feed mechanism comprising two endless screws located in the coal-chute just above the fan, which control the rate of feed of the coal. The fan itself is driven by a 4-HP. motor, arranged for variable speed operation under control of a field rheostat. At the beginning of the operation of charging a retort, the fan is run at a speed of about 400 r. p. m.; its speed is lowered as the charging progresses and the coal requires to be thrown a shorter distance, at such a rate that the speed toward the end of charging is only about 200 r. p. m.

The machine occupies a space about 7 ft. wide, front to rear. Electric current is supplied to it by a trolley wire strung over the track. The machine is able to charge a 20-ft. retort, taking about 1,000 lbs. of coal, in thirty seconds.

A telescopic coke-discharging ram in use at the works of the Paris Gas Co. is shown in Fig. 3. The ram is mounted on a carriage running on the same tracks as the charging machine, and like the latter is operated by electric motors. The ram is in four telescoping sections, of which the inner carries the thrust-plate while the outer or rear section is mounted on the carriage. Four elevating screws driven by a 12-HP. motor enable the ram to be raised or lowered. The same motor also drives the mechanism for thrusting the ram forward. The four sections are all actuated by a single gear, which engages the sections successively as the ram is moved out. The drive is arranged to automatcially reverse and return the ram when it has reached the end of its stroke.

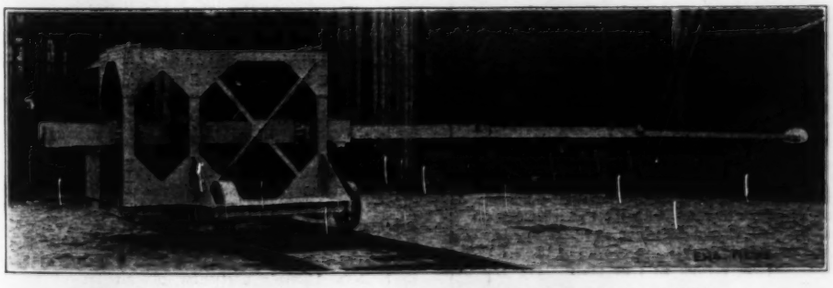

FIG. 3. TELESCOPIC RAM FOR DISCHARGING GAS RETORTS.

THE YELLOW FEVER RECORD AT NEW ORLEANS, according to the report made at 6 p. m., Aug. 28, is as follows: 260 deaths and 1,788 cases to date; 5 deaths, 45 cases and 18 new centers of infection within the past 24 hours; 181 cases under treatment and 420 infection points to date.

THE SEPTIC TANK INFRINGEMENT SUIT AGAINST Pawtucket, R. I., has again been decided in favor of the city, the U. S. Circuit Court of Appeals, on June 13, 1905, having affirmed the decision of the U. S. District Court for Rhode Island. The essential features of the earlier decision were given in our issue of Sept. 8, 1904, while in our issue of Aug. 11, 1904, we gave the substance of the Glover patent specification and claim involved (No. 559,522, issued May 5, 1896). The whole case hinged on whether language of the patent apparently describing covered intermittent filter beds could possibly be stretched to cover the septic tank. Another important claim was that the roofed and ventilated settling tanks described in the Glover patent of 1882 were really septic tanks. The finding of the court in the decision on appeal is as follows:

> Upon full consideration of the whole case we find that the first Glover patent (No 258,744, dated May 30, 1882, and which the complainant holds to cover the septic tank.—Ed.) does not disclose the septic tank, and that the second Glover patent (the one now at issue.—Ed.) is for a system of rapid filtration, comprising two series of filter beds, one inside the ventilated structure and the other outside. It follows that the defendant's apparatus does not infringe the Glover patent in suit by using a septic tank or septic tanks in combination with filtering beds.
>
> The decree of the Circuit Court is affirmed, and the appellee (the city—Ed.) recovers costs of appeal.

The original suit was brought by the American Sewage Disposal Co of Boston in the spring of 1902, as were also suits against Pittsfield, Mass., Liberty, N. Y., and Plainfield, N. J. The village of Liberty settled with the company. The Pittsfield and Plainfield suits are pending. The company talks of an appeal in the Pawtucket case to the U. S. Supreme Court, but the city appears to regard an appeal unlikely, in view of the two sweeping decisions in its favor already obtained. Mr. Geo. A. Carpenter, M.

Am. Soc. C. E., is city engineer of Pawtucket, R. I., and Mr. John N. McClintock is General Manager of the American Sewage Disposal Co., of Boston, which controls the Glover patent.

SAFETY OF MINE HOISTING is the subject of investigation by an expert commission recently appointed by the government of the Transvaal, South Africa. The commission consists of 24 members, including in this number its secretary, Mr. J. R. Mackinlay, of the Transvaal Mines Department. Of this number, all but six are mining or mechanical engineers, and these are mine managers. The commission is therefore of a character promising valuable results.

The commission has outlined the scope of its work in an elaborate schedule of subjects which require answer and upon which comments, testimony, and suggestions are invited. The schedule in detail, covering five large-size printed pages, is too extensive to be reproduced here, but it may be seen at either the New York or the Chicago office of Engineering News by those interested. The main heads of the schedule are: Winding Ropes (structure, material, preservation, examination, testing); Methods of Attaching Rope to Load; Safety Catches and Appliances in Shafts.

The commission not only invites technical evidence on any part of its subject, but also desires to have manufacturers of devices connected with the subject to submit drawings and descriptions (or also models), and to authorize the commission to test these devices at its pleasure. All communications, statements, drawings and models must be dispatched so as to reach the secretary not later than January 31, 1906. They should be addressed P. O. Box 1132, Johannesburg, or Room 74, Winchester House, Johannesburg, Transvaal.

PERSONALS.

Mr. Wilkie Woodard has been appointed Chief Assistant Construction Engineer of the Missouri Pacific Ry.

Mr. Sidney K. Clapp has resigned his position as Assistant Engineer in the U. S. Geological Survey.

Mr. Duncan MacPherson, Division Engineer of the Canadian Pacific Ry., at Montreal, Que., has resigned that position.

Mr. William Turnstall has been elected Superintendent of Public Works of Homestead, Pa., succeeding Mr. Edward D. Lyon, resigned.

Mr. J. G. Sullivan, Division Engineer of the Canadian Pacific Ry., at Winnipeg, Man., has been appointed Assistant Engineer of Construction of the Panama Canal.

Mr. Archibald R. Eldridge, M. Am. Soc. C. E., has been appointed Assistant Bridge Engineer of the Chicago, Burlington & Quincy R. R., with headquarters at Chicago, Ill.

Mr. J. M. R. Fairbairn has been appointed acting Division Engineer of the Eastern Division of the Canadian Pacific Ry., with headquarters at Montreal, Que. He succeeds Mr. D. MacPherson, resigned.

Mr. L. G. Morphy has been appointed Assistant to Mr. C. J. Parker, Principal Assistant Engineer of the New York Central & Hudson River R. R., with headquarters at Grand Central Station, New York City.

Mr. Andrew J. Black has resigned his position as Chief Engineer of Power Stations of the Indiana Union Traction Co. and will go to Chicago to take charge of the power station now being erected by the Chicago & Milwaukee Ry. Co.

Mr. A. O. Cunningham, for some time Bridge Engineer of the Wabash R. R., has been appointed Chief Engineer of that road, succeeding Mr. W. S. Newell, whose resignation of that position is mentioned elsewhere in this column.

Mr. George H. Burgess, heretofore Assistant Engineer of the Northwest System of the Pennsylvania R. R. has been appointed Assistant Engineer of the Erie R. R., in charge of the reconstruction of the terminals and docks at Jersey City, N. J.

Mr. Ole Davidson has been appointed Division Engineer of the Fort Dodge Division of the Chicago Great Western Ry., with headquarters at Clarion, Ia., succeeding Mr. E. M. Grime, transferred to the Northwest Division to succeed Mr. W. C. Church, resigned.

Mr. B. E. Winslow, Architectural Engineer for the Board of Education, Chicago, has been appointed Architectural Engineer for the Building Department of that city, with the special duty of examining plans submitted with applications for building permits.

Mr. Howard S. Reynolds, heretofore Superintendent of the Operating Department of J. G. White & Co., has been appointed Manager of the electric light, street railway and gas properties at Helena, Mont., which were recently acquired by the White Co. and allied interests.

Mr. W. S. Newell, since June, 1902, Chief Engineer of the Wabash R. R., has resigned that position to become a member of the McMyler Manufacturing Co., at Cleveland, O. Previous to becoming connected with the Wabash Mr. Newell was Chief Engineer of the Wheeling & Lake Erie R. R.

Messrs. Oscar F. Lackey, Assoc. M. Am. Soc. C. E., formerly Assistant Engineer, Docks and Piers, Harbor Board, Baltimore, Md.; F. R. Bartles, of Clearfield, Pa., and George T. Kenly, Lake Montebello, Baltimore, Md., have been appointed Assistant Engineers by the Isthmian Canal Commission. They sailed for Panama Aug. 19.

Mr. John B. Newhall, Assoc. M. Am. Soc. M. E., has opened an office at Tompkinsville, New York City, and proposes to make a specialty of underground water supply engineering, designing driven well plants and pumping stations and appurtenances for such. Mr. Newhall has had over 20 years' experience in this line of work, designing many driven well plants in New York and vicinity, New Jersey and in the South.

Mr. W. A. Cattell, M. Am. Soc. C. E., has accepted a position with the banking house of E. H. Rollins & Sons, of Boston, Chicago, Denver and San Francisco, and will look after their engineering work on the Pacific Coast. Mr. Cattell has turned over his consulting practice and New York office to Messrs. Ford & Waldo, Consulting and Contracting Engineers, who will continue such work as he had in hand, and will start for San Francisco about the middle of September.

Mr. C. F. Hurd, formerly Assistant Professor of Experimental Engineering at the Armour Institute of Technology, Chicago, later consulting engineer for Armour & Co., and for the last two years with the Indianapolis Water Co., has been recently appointed Assistant Professor of Applied Mechanics at the University of Illinois. Prof. Hurd will have charge of the Testing Laboratory and will carry on work in connection with the new engineering experiment station which has been established by the state.

Obituary.

C. Frederick Warner, an electrical engineer and contractor, died Aug. 16 at his home in Rockford, Ill., aged 61 years.

J. Herbert Bagg, Secretary and member of the Executive Committee of the General Chemical Co., died Aug. 10 at his home at Bay Ridge, N. Y.

William E. Langdon, President of the Institution of Electrical Engineers of Great Britain during 1901-2, died Aug. 11, aged 73 years. He was until recently Chief Electrical Engineer of the Midland Ry. at Derby.

Walter H. Whitten, President of the Holyoke Machine Co., died Aug. 23 at his home in Holyoke, Mass., aged 78. He was one of the first to become interested in the designing and manufacturing of turbine water wheels.

Heber C. Robinson, Superintendent of the electric light plant at Egg Harbor, N. J., died Aug. 20 at his home in Camden, N. J. Mr. Robinson was interested largely in electrical affairs, and is said to have built the first electric light plant in Camden. He was 65 years old.

John T. Norton, formerly Chief Engineer of the Guatemala Northern Ry. of Central America, died Aug. 5 in New York City, aged 41 years. Mr. Norton entered the employ of the Atchison, Topeka & Santa Fe Ry. in 1886, being engaged on construction work in Kansas and Texas. In 1889 he went to Mexico as construction engineer on the Mexican Central Ry., and later he was engaged as locating engineer on railway enterprises on the Isthmus of Tehuantepec. In 1893 he went to Central America to accept a position on the Guatemala Northern Ry., of which he later became Chief Engineer.

Alfred Waterhouse, R. A., one of the most noted architects of England, died Aug. 22 in London, aged 75 years. He designed some of the most important buildings erected in England during the last 40 years, perhaps his most successful building being Eaton Hall, Cheshire. His work was principally in the applied Gothic style. Mr. Waterhouse was born in Liverpool in 1830. He studied architecture at Manchester under Richard Lane and afterward in France and Italy. In 1878 he became an Associate of the Royal Academy, and in 1885 he became an Academician. He was President of the Royal Institute of British Architects for three years.

Robert Bruce Park, of Athens, Pa., died Aug. 24 as the result of sunstroke. Mr. Park was graduated from Cornell University in 1894 with the degree of Civil Engineer. He was for a number of years with the Union Bridge Co., at Athens, Pa., and was an Assistant Engineer for that company at Dry Tortugas, Fla., in charge of the erection of the naval coaling station at that place. For the past six years he had been in the employ of the Navy Department, Bureau of Yards and Docks, at the Navy Yards at Portsmouth, Va., and League Island, Pa., and at the time of his death was draftsman-in-charge at the latter place. Mr. Park was 36 years of age.

Samuel M. Sears, formerly City Engineer of Kingston, N. Y., and in 1896 Engineering Inspector of Pavements in New York City, died Aug. 20 at his home in Yonkers, N. Y. In 1849 he was engaged in the construction of railroads in Vermont, and some years afterwards he was appointed Resident Engineer of the Great Western R. R., with headquarters in Canada. Later he was employed on the construction of the Erie Canal, and at various other times he occupied positions with the Canada Southern, Chicago, Milwaukee & St. Paul, Norfolk & Western, West Shore Railroads. He superintended the construction of the West Point Tunnel of the last named road. He was 75 years old.

Captain Lyman Hall, President of the Georgia School of Technology, died Aug. 17 in a sanitarium at Dansville, N. Y. His death was due to nervous prostration brought on by overwork. Captain Hall was graduated from the West Point Military Academy in 1881. He then became Commandant of cadets and Professor of Mathematics at Edgewood, Ga., leaving this place in 1883 to go to the South Carolina Military Academy as Assistant Professor of Mathematics. He remained at the South Carolina Military Academy for three years and then returned to Edgewood to resume the chair of Mathematics. In 1888 he became Professor of Mathematics at the Georgia School of Technology, and in 1895 he became President of that institution. The degree of LL. D. was conferred upon him in 1902 by Washington and Lee University. Captain Hall was quite well known as a mathematician and was the author of "Hall's First Chapters in Algebra," "Elements of Algebra" and a key for the same. He was born in Americus, Ga., in 1859.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN PUBLIC WORKS ASSOCIATION.
Chattanooga meeting postponed until further notice because of yellow fever quarantines. Secy., W. H. Flint, Chattanooga, Tenn.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Sept. 5 to 7. Annual meeting at Montreal, Canada. Secy., Geo. W. Tillson, Brooklyn, N. Y.

ROADMASTERS & MAINTENANCE OF WAY ASSOCIATION.
Sept. 12, 14. Annual meeting at Niagara Falls, N. Y. Secy., C. E. Jones, C., B. & Q. Ry., Beardstown, Ill.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 13 to 16. Annual convention at New York, N. Y. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN ELECTROCHEMICAL SOCIETY.
Sept. 18 to 20. Annual meeting at Bethlehem, Pa. Secy., S. S. Sadtler, 39 S. 10th St., Philadelphia, Pa.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 25 to 29. Annual meeting at Boston, Mass. Secy., Dr. Chas. O. Probst, Columbus, O.

AMERICAN STREET RAILWAY ASSOCIATION.
Sept. 25-30. Annual convention at Philadelphia, Pa. Secy., T. C. Penington, 2020 State St., Chicago, Ill.

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.
Oct. 17. Annual meeting at Pittsburg, Pa. Secy., R. F. Patterson, Concord, N. H.

MAINTENANCE OF WAY MASTER PAINTERS' ASSOCIATION.
Nov. 13, 14. Annual meeting at Cincinnati, O. Secy., H. J. Schnell, 100 William St., New York, N. Y.

APPALACHIAN ENGINEERING ASSOCIATION.—The next meeting will be held at the Florentine Hotel, Huntington, W. Va., on Saturday, Sept. 16, at 8 p. m. Secy., H. M. Payne, Williamson, W. Va.

CENTRAL RAILWAY CLUB.—The next meeting of the club will be held on Friday, Sept. 8, at Buffalo, N. Y. The meeting is to take the form of a steamer excursion to Grand Island, starting from the Iroquois Hotel at 1 p. m. A paper will be read by Mr. Geo. Wagstaff (N. Y. C. & H. R.), on "Hydrostatic Tests of Locomotive Boilers." Rules of Interchange will be discussed, in connection with a committee report on the subject. Secy., H. D. Vought, 62 Liberty St., New York.

AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY.—At a meeting of this society to be held in Buffalo, N. Y., on Sept. 14, 15 and 16, a paper entitled "Advantages and Disadvantages of Glasses in Railway Service; with appended report of the opinion of the Ophthalmologists throughout the United States as to the Safeness of an Employe Requiring their Use," will be read Friday morning, September 15 at 9.45. The academy will be pleased to have railroad officials interested in this question attend the meeting and take part in the discussion of the paper. Any inquiries or communications should be addressed to Dr. Geo. A. Suker, Secy., 1101 Columbus Memorial Bldg., Chicago, Ill. Meeting place, Lenox Hotel.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.—The annual summer meeting of the society was held at New Haven, Conn., on Aug. 23, with about 70 members and guests present. The programme of the meeting consisted of a series of excursions to points of interest in the vicinity of the meeting place and of a dinner at Savin Rock, New Haven's particular pleasure resort on the coast of Long Island Sound. Among the engineering works visited was the three-span Melan arch highway bridge at Derby, Conn., and the foundations of the new New York, New Haven & Hartford R. R. bridge over the Housatonic River at Naugatuck Junction. This bridge will consist of two parallel independent double track bridges, each consisting of one riveted truss span of 147 ft., one deck plate girder span of 108½ ft., three pin-connected spans of 217 ft. 7 ins., and a Scherzer rolling lift bridge arranged to give a clear channel of 100 ft. The piers and abutments are of granite and are founded from 15 to 50 ft. below high water by means of cofferdams, open caissons and pneumatic caissons. A short business meeting was held at which 13 new members were elected.